Atlantic
DESIGN ENGINEERS, INC.

March 12, 2021

C. Nils Mckay, Planning Technician
Town Hall
3 North Main Street
Assonet, MA 02702

RE: Large-Scale Solar Energy System Site Plan Review
Middleboro Road Solar Project – Freetown, MA
ADE Project #3220.01

Dear Mr. Mckay:

On behalf of the applicant, CVE North America, Inc., enclosed, please find documents relative to a Site Plan Review application for the Middleboro Road Solar Project located in Freetown, Massachusetts.

We have provided copies of the following items for the Planning Board:

- Three (3) copies of Application for Site Plan Review including all required signatures.
- Deed for the Subject Site.
- Municipal Lien Certificate
- 300-foot Certified Abutters List
- Zoning Determination Letter dated 3/2/2021
- Certificate of Insurance
- Purchase Option Agreement 12/28/19 – Signed 12/20/19 (Site Control)
- Eversource Distributed Generation Project Notification (Utility Notification)
- Preliminary One-Line Electrical Diagram
- Photovoltaic Array Component Documents
- Pollinator Friendly Solar Description and Proposed Seed Mix
- Solar Decommissioning Plan Evaluation and Cost Estimate dated 3/12/2021
- Solar Facility Operation & Maintenance Plan
- Wetlands Delineation Report by Sabatia Inc. – Dated January 8, 2021
- Hazardous Material Assurance Letter – Dated March 12, 2021
- Sound Attenuation Analysis – Dated March 12, 2021
- Zoning Figure

Under Separate Cover:

- One (1) Memory Stick Containing All Above-Listed Documents
- Twelve (12) Full Size Development Plans titled "Site Development Plans for Middleboro Road Solar Project" dated 3/12/2021
- Stormwater Management System Report – Dated 3/12/21

Checks for the Following:

- Site Plan Review Check No. 0363 dated 3/10/21 in the amount of $500.00
- Consultant Fee Check No. 0380 dated 3/10/21 in the amount of $3,500.00

If you have any questions or require further information, please do not hesitate to contact me at (508) 888-9282.

Sincerely,

ATLANTIC DESIGN ENGINEERS, INC.

Richard J. Tabaczynski, P.E.
Vice President

cc: Town Clerk

Site Plan Review
and Supporting Documents
For
Middleboro Road Solar Project
Freetown, Massachusetts

Prepared for:
CVE North America, Inc.
109 W. 27th Street, 8th Floor
New York, New York 10001

Prepared by:
Atlantic Design Engineers, Inc.
P.O. Box 1051
Sandwich, Massachusetts 02563

March 12, 2021
Atlantic Project No. 3220.01

FORM SPR – APPLICATION FOR SITE PLAN REVIEW

PLANNING BOARD
TOWN OF FREETOWN, MASSACHUSETTS
FORM SPR - APPLICATION FOR SITE PLAN REVIEW

Checklist for Applicants:

The following must be included with all applications for site plan review:

☒ 1) Three copies of this form, a copy of the deed to the property, and if the application is submitted by anyone other than the owner, a letter signed in the presence of a notary public authorizing the applicant to act on their behalf.

☒ 2) 12 copies of the plan prepared in accordance with the Town of Freetown Subdivision Rules and Regulations and the Town of Freetown Site Plan Review Regulations. All plan copies must be folded.

☒3) An application fee according to the fee schedule payable to the Town of Freetown. Applicant shall also be responsible for costs associated with advertising and certified mailing of public hearing notices.

☒4) A PDF electronic file of the plan on a CD including any drainage calculations, Development Impact Statements, or Traffic Studies.

☒5) A Municipal Lien Certificate

☒6) A certified abutters list from the Town of Freetown Board of Assessors.

☒7) Engineering Review deposit

☒ 8) Zoning Determination from the Zoning Enforcement Officer/Building Commissioner

To the Town Clerk of the Town of Freetown Massachusetts:

The undersigned hereby submits the accompanying Special Permit Application and supporting documents for Special Permit Approval under the Rules and Regulations of the Planning Board adopted hereunder.

1. Applicant: CVE North America, Inc. Tel:(603) 545-2930

   Address: 109 W. 27th Street, 8th Floor New York, NY 10001

2. Attorney: Elizabeth F. Mason Tel:(617) 502-6286

   Address: 20 Park Plaza #402 Boston, MA 02116

3. Owner: Trustees of the Middleboro Road Nominee Trust (Clermont, Edmond J& Richard P & Clermont Armand R & Robert ET) Tel:XXX-XXX-XXXX

Address: PO Box 711 East Freetown MA 02717

4. Designer: Atlantic Design Engineers, Inc. Tel:(508) 888-9282

Address: PO Box 1051 Sandwich MA 02563

5. Plan Entitled: Site Development Plans for Middleboro Road Solar Project

6. Plan Dated: March 12, 2021

7. Project Location: 32 Middleboro Road, Freetown MA

Address:32 Middleboro Road, Freetown MA

8. Assessor Map/Parcel No.Map 245 Parcels 30.01-07 Zoning District: Residential

9. Lot Area: ±16.1-acres Number of Lots Proposed: N/A

Total Acreage of Tract ±16.1-acres Total Percentage of Lot Coverage Proposed: N/A

10. Total Square Footage of Existing Structures: 1,602 sqft

Total Square Footage of Proposed Structures: N/A

Combined Square Footage of Existing and Proposed Structures: 1,602 sqft

11. Total Number of Parking Spaces (Existing): N/A

Total Number of Regular Parking Spaces Proposed: N/A

Total Number of Handicapped Parking Spaces Proposed: N/A

Total Number of Spaces for Deliveries Proposed: N/A

12. Detailed Description of Project (use additional pages as added)

Proposed ground mounted fenced in solar array at 32 Middleboro Road, Freetown MA. The project proposes the installation of approximately ±7,176 photovoltaic panels along with perimeter fencing, racking systems, inverters, transformers, and battery storage units with associated concrete pads, above and below ground utilities, stormwater facilities, and a gravel road to access all electrical equipment pads. Access to the project will be via Clermont Way through an extension of the existing private way. The total proposed fenced in area is ±8.5-acres

13. Deed of Property Recorded in Bristol County Fall River District Registry of Deeds in Plan Book 3508 Page 28 Date Acquired: November 06, 1998.

14. Estimated Cost of Construction: ~$4.5 mil Type: ☒new ☐reconstruction ☐ alteration

15. Application Fee – based on fee schedule: $500.00

To: Board of Health, Conservation Commission, Planning/Land Use Administrator, Building Inspector, Highway Department, Fire Department, and Police Department.

According to the Special Permit Regulations in the Town of Freetown Protective By-Laws, you have the option to examine and to make recommendations on this plan and to submit your report to the Planning Board office on or before ______________________ (35 days from date of transmittal by the Town Clerk). Recommendations may be indicated directly on the attached plan or on separate cover.

The property owner of record should be present when submitting plans for the Planning Board's consideration. If the owner is not present, he or she shall be represented by an authorized agent with a notarized letter of authorization. All plans must be prepared and endorsed by a Professional Land Surveyor, licensed in the Commonwealth of Massachusetts.

Owner's signature and address if not the applicant or applicant's authorization if not the owner

x Richard P Clermont 6 CLERMONT WAY E. FREETOWN MA

Owner's Signature **Owner's Address**

Richard P. Clermont 508-763-4388

Owner's Printed Name **Owner's Phone Number**

CVE NORTHAMERICA
109 W. 27th ST NY, NY 10001

Applicant's Signature **Applicant's Address**

RYAN YOUNG 603-545-2930

Applicant's Printed Name **Applicant's Phone Number**

ryan.young@cvegroup.com

Applicant's E-Mail Address **Owner's E-Mail Address**

COMMONWEALTH OF MASSACHUSETTS

Bristol,SS March 10, 2021

On this 10 day of MARCH, 2021, before me, the undersigned Notary Public, personally appeared RICHARD P. CLERMONT and proved to me through satisfactory evidence of identification, which is DRIVERS LICENSE, to be the person whose name is signed on the preceding or attached document, and acknowledged to me that they signed it voluntarily for its stated purpose.

Abby R. Clermont
Notary Public
My Commission Expires: 3/1/24
Abby R. Clermont

Date Received by Town Clerk:

RECEIVED BY TOWN CLERK

DATE: ______________________

TIME ______________________

SIGNATURE ______________________

March 5 ,2020

Mr. Keven V. Desmarais, Chairman
Freetown Planning Board
3 North Main Street
Assonet, MA 02702

Dear Chairman Desmarais,

The Freetown Planning Board FORM SPR – APPLICATION FOR SITE PLAN REVIEW states that "the property owner of record should be present when submitting plans for the Planning Board's consideration. If the owner is not present, he or she shall be represented by an authorized agent with a notarized letter of authorization."

I cannot be present at the time of submission, but I am authorizing CVE North America Inc. and Atlantic Design Engineers to submit the Site Plan Application and associated plans on my behalf.

Sincerely,

RICHARD P. ___ Clermont, Richard Clermont
Property Owner, 32 Middleboro Road
RPC

COMMONWEALTH OF MASSACHUSETTS

COUNTY OF Bristol

On this 10 day of March, 2021, before me, the undersigned notary public, personally appeared, Richard P. Clermont, who proved to me through satisfactory evidence of identification, which was Drivers lisence, to be the person whose name is signed on the preceding or attached document, and acknowledged to me that he/she signed it voluntarily for its stated purpose, as such Trustee as aforesaid.

Abby R. Clermont
Printed Name: Abby R. Clermont
My Commission Expires: 3/1/24

SUBJECT SITE DEED

BK 3508 PG 28
11/06/98 12:27 DOC. 20140

QUITCLAIM DEED

I, Claire D. Clermont,

of 32 Middleboro Road, East Freetown, Bristol County, Massachusetts

being unmarried, and in full consideration of One Dollar,

under power reserved in deed of Claire D. Clermont to Claire D. Clermont et al, dated November 21, 1996 and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 3176, Page 74,

grant all my right, title and interest to EDMOND J. CLERMONT, 2624 Northeast 24th Street, Lighthouse Point, Florida, RICHARD P. CLERMONT, 6 Clermont Way East Freetown, Bristol County, Massachusetts, ARMAND R. CLERMONT, 5 Tommy's Lane East Freetown, Bristol County, Massachusetts and ROBERT E. CLERMONT, 70 Old Purchase Road, Edgartown, Dukes County, Massachusetts, as Trustees of the Middleboro Road Nominee Trust, recorded in the Bristol County (Fall River District), Registry of Deeds in Book 3176, Page 78,

East Freetown, MA

with **quitclaim covenants**

Some angle issues

the land in East Freetown, County of Bristol, Commonwealth of Massachusetts, with all the buildings thereon, bounded and described as follows:

Beginning at the north-west corner of said land in line of the Public Road leading from New Bedford to Middleborough, at the south-west corner of land formerly of Edward R. Ashley;

thence by said Ashley land south 86 1/4°East, by the wall, twenty-nine and 56/100 (29.56) rods to an angle; 487.74

thence south 85 1/2°East, by the wall, seven and 6/10 (7.6) rods to an angle; 125.4

thence south 86 3/4°East, by the wall, ten and 2/10 (10.2) rods to the corner of the wall; 168.3

thence south 85 1/4°East sixteen (16) rods to the north-east corner of the land hereby conveyed, to a stake and stones; 264

WRONG

thence south 87 1/2°West by land formerly of James Ashley, twenty-one and 12/100 (21.12) rods to a stake and stones at a corner; 348.48

thence south 83 1/2°East five and 28/100 (5.28) rods to a stake and stones at a corner; 87.12

thence by land formerly of Ebenezer White, south 85 3/4°West, twenty-five and 4/10 (25.4) rods to a stake and stones for a corner; 419.1

THE ADDRESS IN THE MARGIN IS NOT A PART OF THIS CONVEYANCE. ITS ACCURACY HAS NOT BEEN VERIFIED.

thence by land formerly of said White North 86° West, thirteen and 92/100 (13.92) rods to the end of a wall; 231

thence by said White land and the wall North 85°West, twenty-seven and 36/100 (27.36) rods to an angle; 45.4

N

thence by said White land and the wall 86 1/2°West, twenty-one and 16/100 (21.16) rods to a corner of a wall; 349

thence by the wall and the dower land of Cynthia Ashley, North 5° East, fourteen and 32/100 (14.32) rods to an angle; 236.28

thence by said wall and dower land, North 40 1/2°West, one and 28/100 rods to an angle; 21

thence by said wall and dower land, north 78 3/4° West, about eleven and 16/100 (11.16) rods to the northeast corner of said dower land; 184.14

thence by said dower land, north 85 1/2° West, about twelve and 44/100 (12.44) rods to said Road; 205.26

thence by said road, northerly about sixteen and 24/10 (16.24) rods to an angle; 268

thence by said road northerly six (6) rods to the place of beginning. 99

Containing Nineteen (19) Acres and nine (9) rods, be the same more or less, according to the survey and plan of Alden White.

Excepting therefrom that portion of the premises above-described conveyed to Roger Clermont, et ux, by deed dated June 25, 1973 and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 1076, Page 493. See also Corrective Deed dated February 25, 1975, recorded in said Registry of Deeds in Book 1076, Page 494. 9C

Excepting therefrom that portion of the premises above-described conveyed to Edmond J. Clermont, ex ux, by deed dated October 16, 1963, and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 811, Page 449. Lot 1

Excepting therefrom that portion of the premises above-desribed conveyed to Armand R. Clermont, et ux, by deed dated October 26, 1966 and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 891, Page 447. Lot 2

Excepting therefrom that portion of the premises above described conveyed to Richard P. Clermont, et ux, by deed dated June 25, 1973, and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 1076, Page 493. See also corrective deed dated February 18, 1975, recorded in said Registry of Deeds in Book 1111, Page 785.

Being the same premises conveyed to this grantor et al by deed of this grantor, dated November 21, 1996 and recorded in the Bristol County (Fall River District) Registry of Deeds in Book 3176, Page 74.

NO TITLE EXAMINATION

Executed as a sealed instrument this third day of November, 1998.

Claire D. Clermont
Claire D. Clermont

The Commonwealth of Massachusetts

Bristol ss. November 3, 1998

Then personally appeared the above named Claire D. Clermont and acknowledged the foregoing instrument to be her free act and deed.

Before me, Richard A. Bachand
Richard A. Bachand - Notary Public
My commission expires Nov. 12, 2004

CERTIFIED ABUTTERS LIST & NOTIFICATION TO ABUTTERS

THE COMMONWEALTH OF MASSACHUSETTS
TOWN OF FREETOWN
PLANNING BOARD

NOTICE OF PUBLIC HEARING

As provided in the Massachusetts General Laws Chapter 40A and Freetown Protective Bylaws Article XI Section 23 the Site Plan Review By-law, the Planning Board, acting as the Site Plan Review Authority, will hold a public hearing on the application of **CVE North America, Inc. f**or a **Site Plan Review** for property located on **32 Middleboro Road, Freetown, MA 02717** as per the attached notice:

Pursuant to Governor Baker's March 12, 2020 Order Suspending Certain Provisions of the Open Meeting Law, G.L. c. 30A, §18, and the Governor's March 15, 2020 Order imposing strict limitation on the number of people that may gather in one place, these public hearings will be conducted via remote participation to the greatest extent possible. Members of the public attending this hearing virtually will be allowed to comment during the portion of the hearing designated for public comment. Instructions for attending and participating in the hearing can be found at: **https://www.freetownma.gov/planning-board/pages/planning-board-virtual-meeting-information**

The Town of Freetown Planning Board will conduct a public hearing on **Tuesday, April 6, 2020** at **6:00 pm** to act on the application of **CVE North America, Inc.** The applicant has submitted a site plan review application and plan entitled **Site Development Plans for Middleboro Road Solar Project** and dated **March 12, 2021** proposing a large scale solar photovoltaic facility located on approximately 8.5 acres of land located on **Assessors Map 245, Parcels 30-01, 30-02, 30-03, 30-04, 30-05, 30-06, and 30-07.**

A copy of the plan may be reviewed at the office of the Town Clerk and Planning Board, Freetown Town Hall during normal business hours. All persons, parties or corporations interested therein may appear and be heard in relation thereto.

Town of Freetown Planning Board

C. Nils McKay
Planning Technician

300 foot Abutters List Report
Freetown, MA
March 05, 2021

Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.06		CLERMONT ARMAND R & ROBERT E T
Property Address:	10 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.07		CLERMONT ARMAND R & ROBERT E T
Property Address:	8 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-031	Mailing Address:	CLERMONT RICHARD P & CAROL A
CAMA Number:	245-031		6 CLERMONT WAY
Property Address:	6 CLERMONT WAY		E FREETOWN, MA 02717
Parcel Number:	245-032	Mailing Address:	CLERMONT DAVID & HOPKINS
CAMA Number:	245-032		SHELLEY
Property Address:	4 CLERMONT WAY		4 CLERMONT WAY
			E FREETOWN, MA 02717
Parcel Number:	245-033	Mailing Address:	VEIGA JOHN J
CAMA Number:	245-033		P O BOX 51
Property Address:	26 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-039	Mailing Address:	ITALIAN HOME FOR CHILDREN INC
CAMA Number:	245-039		1125 CENTRE STREET
Property Address:	9 PINEWOOD CT		JAMAICA PLAIN, MA 02130
Parcel Number:	245-131	Mailing Address:	OLIVEIRA BROS MATERIALS LLC
CAMA Number:	245-131		68 COUNTY RD
Property Address:	68 COUNTY RD		E FREETOWN, MA 02717
Parcel Number:	245-137	Mailing Address:	MELLO LINDA F
CAMA Number:	245-137		25 MIDDLEBORO ROAD
Property Address:	25 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-138	Mailing Address:	MELLO TIMOTHY M & ANGELA P TRS
CAMA Number:	245-138		MELLO FAMILY INVESTMENT TRUST
Property Address:	27 MIDDLEBORO RD		P O BOX 684
			E FREETOWN, MA 02717
Parcel Number:	245-139	Mailing Address:	OLIVEIRA BROS MATERIALS LLC
CAMA Number:	245-139		33 MIDDLEBORO RD
Property Address:	31 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-139.01	Mailing Address:	OLIVEIRA BROS MATERIALS LLC
CAMA Number:	245-139.01		33 MIDDLEBORO RD
Property Address:	33 MIDDLEBORO RD		E FREETOWN, MA 02717

Michael T. McCue

3/5/2021

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030		CLERMONT ARMAND R & ROBERT E T
Property Address:	32 MIDDLEBORO RD		P O BOX 711
			E FREETOWN, MA 02717

Abutters:

Parcel Number:	243-058.01	Mailing Address:	ASHLEY FRANK H JR
CAMA Number:	243-058.01		52 MIDDLEBORO RD
Property Address:	52 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-059	Mailing Address:	AMBROSE MARK
CAMA Number:	243-059		44 MIDDLEBORO RD
Property Address:	44 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-060	Mailing Address:	MELLO ZACHARY M & ASHLEY MAE
CAMA Number:	243-060		40 MIDDLEBORO RD
Property Address:	40 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-061	Mailing Address:	SHEPARD JASON A
CAMA Number:	243-061		38 MIDDLEBORO RD
Property Address:	38 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-062	Mailing Address:	FREETOWN HOLDINGS LLC
CAMA Number:	243-062		37 MIDDLEBORO RD
Property Address:	37 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-063	Mailing Address:	FRAGA MARIA U & DASILVA CONNIE
CAMA Number:	243-063		39 MIDDLEBORO RD
Property Address:	39 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-027	Mailing Address:	CLERMONT ARMAND R
CAMA Number:	245-027		P O BOX 711
Property Address:	36 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-028	Mailing Address:	MONIZ DINARTE M & DEBORAH M
CAMA Number:	245-028		34 MIDDLEBORO RD
Property Address:	34 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-029	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-029		CLERMONT ARMAND R & ROBERT E T
Property Address:	0 ROAD CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.01	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.01		CLERMONT ARMAND R & ROBERT E T
Property Address:	7 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-030.02	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.02		CLERMONT ARMAND R & ROBERT E T
Property Address:	9 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.05	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.05		CLERMONT ARMAND R & ROBERT E T
Property Address:	12 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.06		CLERMONT ARMAND R & ROBERT E T
Property Address:	10 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.07		CLERMONT ARMAND R & ROBERT E T
Property Address:	8 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-031	Mailing Address:	CLERMONT RICHARD P & CAROL A
CAMA Number:	245-031		6 CLERMONT WAY
Property Address:	6 CLERMONT WAY		E FREETOWN, MA 02717
Parcel Number:	245-032	Mailing Address:	CLERMONT DAVID & HOPKINS
CAMA Number:	245-032		SHELLEY
Property Address:	4 CLERMONT WAY		4 CLERMONT WAY
			E FREETOWN, MA 02717
Parcel Number:	245-033	Mailing Address:	VEIGA JOHN J
CAMA Number:	245-033		P O BOX 51
Property Address:	26 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-138	Mailing Address:	MELLO TIMOTHY M & ANGELA P TRS
CAMA Number:	245-138		MELLO FAMILY INVESTMENT TRUST
Property Address:	27 MIDDLEBORO RD		P O BOX 684
			E FREETOWN, MA 02717
Parcel Number:	245-139	Mailing Address:	OLIVEIRA BROS MATERIALS LLC
CAMA Number:	245-139		33 MIDDLEBORO RD
Property Address:	31 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-139.01	Mailing Address:	OLIVEIRA BROS MATERIALS LLC
CAMA Number:	245-139.01		33 MIDDLEBORO RD
Property Address:	33 MIDDLEBORO RD		E FREETOWN, MA 02717

Michael T. McCue

3/5/2021

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030.01	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.01		CLERMONT ARMAND R & ROBERT E T
Property Address:	7 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

Abutters:

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Property Address:	52 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-059	Mailing Address:	AMBROSE MARK
CAMA Number:	243-059		44 MIDDLEBORO RD
Property Address:	44 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-060	Mailing Address:	MELLO ZACHARY M & ASHLEY MAE
CAMA Number:	243-060		40 MIDDLEBORO RD
Property Address:	40 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	243-061	Mailing Address:	SHEPARD JASON A
CAMA Number:	243-061		38 MIDDLEBORO RD
Property Address:	38 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-026	Mailing Address:	ASHLEY JOHN S & ELIZABETH D
CAMA Number:	245-026		68 KEENE RD
Property Address:	26 KEENE RD		EAST FREETOWN, MA 02717
Parcel Number:	245-027	Mailing Address:	CLERMONT ARMAND R
CAMA Number:	245-027		P O BOX 711
Property Address:	36 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-029	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-029		CLERMONT ARMAND R & ROBERT E T
Property Address:	0 ROAD CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030		CLERMONT ARMAND R & ROBERT E T
Property Address:	32 MIDDLEBORO RD		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.02	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.02		CLERMONT ARMAND R & ROBERT E T
Property Address:	9 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.03	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.03		CLERMONT ARMAND R & ROBERT E T
Property Address:	11 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-030.05	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.05		
Property Address:	12 CLERMONT WAY		
Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.06		
Property Address:	10 CLERMONT WAY		
Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.07		
Property Address:	8 CLERMONT WAY		
Parcel Number:	245-031	Mailing Address:	CLERMONT RICHARD P & CAROL A 6 CLERMONT WAY E FREETOWN, MA 02717
CAMA Number:	245-031		
Property Address:	6 CLERMONT WAY		
Parcel Number:	245-032	Mailing Address:	CLERMONT DAVID & HOPKINS SHELLEY 4 CLERMONT WAY E FREETOWN, MA 02717
CAMA Number:	245-032		
Property Address:	4 CLERMONT WAY		

Michael T. McCue

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300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030.02	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.02		
Property Address:	9 CLERMONT WAY		

Abutters:

Parcel Number:	243-058.01	Mailing Address:	ASHLEY FRANK H JR 52 MIDDLEBORO RD E FREETOWN, MA 02717
CAMA Number:	243-058.01		
Property Address:	52 MIDDLEBORO RD		
Parcel Number:	243-059	Mailing Address:	AMBROSE MARK 44 MIDDLEBORO RD E FREETOWN, MA 02717
CAMA Number:	243-059		
Property Address:	44 MIDDLEBORO RD		
Parcel Number:	245-026	Mailing Address:	ASHLEY JOHN S & ELIZABETH D 68 KEENE RD EAST FREETOWN, MA 02717
CAMA Number:	245-026		
Property Address:	26 KEENE RD		
Parcel Number:	245-029	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-029		
Property Address:	0 ROAD CLERMONT WAY		
Parcel Number:	245-030	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030		
Property Address:	32 MIDDLEBORO RD		
Parcel Number:	245-030.01	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.01		
Property Address:	7 CLERMONT WAY		
Parcel Number:	245-030.03	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.03		
Property Address:	11 CLERMONT WAY		
Parcel Number:	245-030.04	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.04		
Property Address:	14 CLERMONT WAY		
Parcel Number:	245-030.05	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.05		
Property Address:	12 CLERMONT WAY		
Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.06		
Property Address:	10 CLERMONT WAY		

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Freetown, MA
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Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.07		
Property Address:	8 CLERMONT WAY		
Parcel Number:	245-031	Mailing Address:	CLERMONT RICHARD P & CAROL A 6 CLERMONT WAY E FREETOWN, MA 02717
CAMA Number:	245-031		
Property Address:	6 CLERMONT WAY		

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Freetown, MA
March 05, 2021

Subject Property:

Parcel Number	CAMA Number	Property Address	Mailing Address
245-030.03	245-030.03	11 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717

Abutters:

Parcel Number	CAMA Number	Property Address	Mailing Address
243-058.01	243-058.01	52 MIDDLEBORO RD	ASHLEY FRANK H JR 52 MIDDLEBORO RD E FREETOWN, MA 02717
245-025	245-025	28 KEENE RD	PERRY JASON M 28 KEENE RD E FREETOWN, MA 02717
245-026	245-026	26 KEENE RD	ASHLEY JOHN S & ELIZABETH D 68 KEENE RD EAST FREETOWN, MA 02717
245-029	245-029	0 ROAD CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.01	245-030.01	7 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.02	245-030.02	9 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.04	245-030.04	14 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.05	245-030.05	12 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.06	245-030.06	10 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
245-030.07	245-030.07	8 CLERMONT WAY	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number: 245-039
CAMA Number: 245-039
Property Address: 9 PINEWOOD CT

Mailing Address: ITALIAN HOME FOR CHILDREN INC
1125 CENTRE STREET
JAMAICA PLAIN, MA 02130

Michael T. McCue

3/5/2021

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030.04	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.04		CLERMONT ARMAND R & ROBERT E T
Property Address:	14 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

Abutters:

Parcel Number:	245-024	Mailing Address:	KEENE PROPERTIES, LLC
CAMA Number:	245-024		8 PARK PLACE
Property Address:	32 KEENE RD		MATTAPOISETT, MA 02739
Parcel Number:	245-025	Mailing Address:	PERRY JASON M
CAMA Number:	245-025		28 KEENE RD
Property Address:	28 KEENE RD		E FREETOWN, MA 02717
Parcel Number:	245-026	Mailing Address:	ASHLEY JOHN S & ELIZABETH D
CAMA Number:	245-026		68 KEENE RD
Property Address:	26 KEENE RD		EAST FREETOWN, MA 02717
Parcel Number:	245-029	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-029		CLERMONT ARMAND R & ROBERT E T
Property Address:	0 ROAD CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.02	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.02		CLERMONT ARMAND R & ROBERT E T
Property Address:	9 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.03	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.03		CLERMONT ARMAND R & ROBERT E T
Property Address:	11 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.05	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.05		CLERMONT ARMAND R & ROBERT E T
Property Address:	12 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.06		CLERMONT ARMAND R & ROBERT E T
Property Address:	10 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-038	Mailing Address:	REINA JAVIER A & MARIA F
CAMA Number:	245-038		7 PINEWOOD CT
Property Address:	7 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-039	Mailing Address:	ITALIAN HOME FOR CHILDREN INC
CAMA Number:	245-039		1125 CENTRE STREET
Property Address:	9 PINEWOOD CT		JAMAICA PLAIN, MA 02130

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-040	Mailing Address:	LAWRENCE DONALD R & LYNN S LAWRENCE FAMILY NOMINEE TRUST 10--12 PINEWOOD CT E FREETOWN, MA 02717
CAMA Number:	245-040		
Property Address:	10 -12 PINEWOOD CT		

Michael T. McCue
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300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030.05	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.05		CLERMONT ARMAND R & ROBERT E T
Property Address:	12 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

Abutters:

Parcel Number:	245-024	Mailing Address:	KEENE PROPERTIES, LLC
CAMA Number:	245-024		8 PARK PLACE
Property Address:	32 KEENE RD		MATTAPOISETT, MA 02739
Parcel Number:	245-025	Mailing Address:	PERRY JASON M
CAMA Number:	245-025		28 KEENE RD
Property Address:	28 KEENE RD		E FREETOWN, MA 02717
Parcel Number:	245-026	Mailing Address:	ASHLEY JOHN S & ELIZABETH D
CAMA Number:	245-026		68 KEENE RD
Property Address:	26 KEENE RD		EAST FREETOWN, MA 02717
Parcel Number:	245-029	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-029		CLERMONT ARMAND R & ROBERT E T
Property Address:	0 ROAD CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030		CLERMONT ARMAND R & ROBERT E T
Property Address:	32 MIDDLEBORO RD		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.01	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.01		CLERMONT ARMAND R & ROBERT E T
Property Address:	7 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.02	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.02		CLERMONT ARMAND R & ROBERT E T
Property Address:	9 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.03	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.03		CLERMONT ARMAND R & ROBERT E T
Property Address:	11 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.04	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.04		CLERMONT ARMAND R & ROBERT E T
Property Address:	14 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717
Parcel Number:	245-030.06	Mailing Address:	CLERMONT EDMOND J& RICHARD P &
CAMA Number:	245-030.06		CLERMONT ARMAND R & ROBERT E T
Property Address:	10 CLERMONT WAY		P O BOX 711
			E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.07		
Property Address:	8 CLERMONT WAY		
Parcel Number:	245-031	Mailing Address:	CLERMONT RICHARD P & CAROL A 6 CLERMONT WAY E FREETOWN, MA 02717
CAMA Number:	245-031		
Property Address:	6 CLERMONT WAY		
Parcel Number:	245-037	Mailing Address:	WENDLING MICHAEL S & LINDA 5 PINEWOOD COURT E FREETOWN, MA 02717
CAMA Number:	245-037		
Property Address:	5 PINEWOOD CT		
Parcel Number:	245-038	Mailing Address:	REINA JAVIER A & MARIA F 7 PINEWOOD CT E FREETOWN, MA 02717
CAMA Number:	245-038		
Property Address:	7 PINEWOOD CT		
Parcel Number:	245-039	Mailing Address:	ITALIAN HOME FOR CHILDREN INC 1125 CENTRE STREET JAMAICA PLAIN, MA 02130
CAMA Number:	245-039		
Property Address:	9 PINEWOOD CT		
Parcel Number:	245-040	Mailing Address:	LAWRENCE DONALD R & LYNN S LAWRENCE FAMILY NOMINEE TRUST 10--12 PINEWOOD CT E FREETOWN, MA 02717
CAMA Number:	245-040		
Property Address:	10 -12 PINEWOOD CT		

Michael T. McCue
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300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number: 245-030.06
CAMA Number: 245-030.06
Property Address: 10 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Abutters:

Parcel Number: 245-029
CAMA Number: 245-029
Property Address: 0 ROAD CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030
CAMA Number: 245-030
Property Address: 32 MIDDLEBORO RD

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.01
CAMA Number: 245-030.01
Property Address: 7 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.02
CAMA Number: 245-030.02
Property Address: 9 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.03
CAMA Number: 245-030.03
Property Address: 11 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.04
CAMA Number: 245-030.04
Property Address: 14 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.05
CAMA Number: 245-030.05
Property Address: 12 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-030.07
CAMA Number: 245-030.07
Property Address: 8 CLERMONT WAY

Mailing Address: CLERMONT EDMOND J& RICHARD P &
CLERMONT ARMAND R & ROBERT E T
P O BOX 711
E FREETOWN, MA 02717

Parcel Number: 245-031
CAMA Number: 245-031
Property Address: 6 CLERMONT WAY

Mailing Address: CLERMONT RICHARD P & CAROL A
6 CLERMONT WAY
E FREETOWN, MA 02717

Parcel Number: 245-032
CAMA Number: 245-032
Property Address: 4 CLERMONT WAY

Mailing Address: CLERMONT DAVID & HOPKINS
SHELLEY
4 CLERMONT WAY
E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-037	Mailing Address:	WENDLING MICHAEL S & LINDA
CAMA Number:	245-037		5 PINEWOOD COURT
Property Address:	5 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-038	Mailing Address:	REINA JAVIER A & MARIA F
CAMA Number:	245-038		7 PINEWOOD CT
Property Address:	7 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-039	Mailing Address:	ITALIAN HOME FOR CHILDREN INC
CAMA Number:	245-039		1125 CENTRE STREET
Property Address:	9 PINEWOOD CT		JAMAICA PLAIN, MA 02130
Parcel Number:	245-040	Mailing Address:	LAWRENCE DONALD R & LYNN S
CAMA Number:	245-040		LAWRENCE FAMILY NOMINEE TRUST
Property Address:	10 -12 PINEWOOD CT		10--12 PINEWOOD CT
			E FREETOWN, MA 02717

Michael T. McCue

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Subject Property:

Parcel Number:	245-030.07	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
CAMA Number:	245-030.07		
Property Address:	8 CLERMONT WAY		

Abutters:

Parcel Number: CAMA Number: Property Address:	245-028 245-028 34 MIDDLEBORO RD	Mailing Address:	MONIZ DINARTE M & DEBORAH M 34 MIDDLEBORO RD E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-029 245-029 0 ROAD CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030 245-030 32 MIDDLEBORO RD	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030.01 245-030.01 7 CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030.02 245-030.02 9 CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030.03 245-030.03 11 CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030.05 245-030.05 12 CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-030.06 245-030.06 10 CLERMONT WAY	Mailing Address:	CLERMONT EDMOND J& RICHARD P & CLERMONT ARMAND R & ROBERT E T P O BOX 711 E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-031 245-031 6 CLERMONT WAY	Mailing Address:	CLERMONT RICHARD P & CAROL A 6 CLERMONT WAY E FREETOWN, MA 02717
Parcel Number: CAMA Number: Property Address:	245-032 245-032 4 CLERMONT WAY	Mailing Address:	CLERMONT DAVID & HOPKINS SHELLEY 4 CLERMONT WAY E FREETOWN, MA 02717

300 foot Abutters List Report

Freetown, MA
March 05, 2021

Parcel Number:	245-033	Mailing Address:	VEIGA JOHN J
CAMA Number:	245-033		P O BOX 51
Property Address:	26 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-034	Mailing Address:	PACHECO CHRISTOPHER H
CAMA Number:	245-034		24 MIDDLEBORO ROAD
Property Address:	24 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-035	Mailing Address:	HARRIS DOUGLAS
CAMA Number:	245-035		22 MIDDLEBORO RD
Property Address:	22 MIDDLEBORO RD		E FREETOWN, MA 02717-1725
Parcel Number:	245-036	Mailing Address:	THOMAS DONALD N JR & DIANA L
CAMA Number:	245-036		20 MIDDLEBORO RD
Property Address:	20 MIDDLEBORO RD		E FREETOWN, MA 02717
Parcel Number:	245-037	Mailing Address:	WENDLING MICHAEL S & LINDA
CAMA Number:	245-037		5 PINEWOOD COURT
Property Address:	5 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-038	Mailing Address:	REINA JAVIER A & MARIA F
CAMA Number:	245-038		7 PINEWOOD CT
Property Address:	7 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-039	Mailing Address:	ITALIAN HOME FOR CHILDREN INC
CAMA Number:	245-039		1125 CENTRE STREET
Property Address:	9 PINEWOOD CT		JAMAICA PLAIN, MA 02130
Parcel Number:	245-041	Mailing Address:	GAOETTE ROBERT M
CAMA Number:	245-041		6-8 PINEWOOD CT
Property Address:	6 -8 PINEWOOD CT		E FREETOWN, MA 02717
Parcel Number:	245-042	Mailing Address:	OLIVEIRA JAMES & DONNA
CAMA Number:	245-042		4 PINEWOOD COURT
Property Address:	4 PINEWOOD CT		E FREETOWN, MA 02717

Michael T. McCue

3/5/2021

ZONING DETERMINATION LETTER

TOWN OF FREETOWN
OFFICE OF THE
BUILDING COMMISSIONER
3 North Main Street
P.O. Box 438 - Assonet, Massachusetts 02702
Tel. (508) 644-2202
Fax (508) 644-2183

March 2, 2021

Asa Smith, Atlantic Design Engineers, Inc.
PO Box 1051
Sandwich, Ma 02563

Re: Zoning Determination

Dear Asa,

This office has received an application for a Zoning Determination to construct a large ground mounted solar at **32 Middleboro Road Parcel 245-030.** The Application lists 245-030 & 254-030.01 as the potential site. Lot 245-030 is recognized as a single lot and 254-030-01 is not a recognized lot. The determination for the application does allow for the ground solar to be constructed on lot 245-030 as recognized but will need a special permit for the site plan review by the Planning Board. With the new information brought in front of me my ruling has changed to an approval.

You have the right to appeal my decision to appeal to the Zoning Board of Appeals. The forms can be obtained from the Town Clerks office during normal business hours. Which you would have 30 days to appeal.

Very Truly Yours,

Jeffrey Chandler

Building Commissioner, Zoning Enforcement Officer

Cc: Office file, Town Clerk, Zoning Board of Appeals.

MUNICIPAL LIEN CERTIFICATE

CERTIFICATE OF INSURANCE

CVENORT-01 JHOGAN

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 11/20/2020

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Roblin Insurance, a division of EPIC
144 Gould Street Suite 100
Needham, MA 02494

CONTACT NAME:
PHONE (A/C, No, Ext): (781) 455-0700 | FAX (A/C, No): (781) 449-8976
E-MAIL ADDRESS: certificates@roblininsurance.com

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : AXIS Specialty Europe SE- London Branch	
INSURER B : Lloyd's of London	15792
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
CVE North America, Inc.
109W 27th St., 8th Floor
New York, NY 10011

COVERAGES **CERTIFICATE NUMBER:** **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY						EACH OCCURRENCE	$ 1,000,000
	CLAIMS-MADE / X OCCUR			3386420220ES	11/1/2020	11/1/2021	DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 1,000,000
	X Hired/Non Owned Auto						MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 1,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 2,000,000
	POLICY / X PRO-JECT / LOC						PRODUCTS - COMP/OP AGG	$ 2,000,000
	OTHER:						HNO Auto	$ 1,000,000
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
	ANY AUTO						BODILY INJURY (Per person)	$
	OWNED AUTOS ONLY / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	HIRED AUTOS ONLY / NON-OWNED AUTOS ONLY						PROPERTY DAMAGE (Per accident)	$
								$
A	X UMBRELLA LIAB / X OCCUR						EACH OCCURRENCE	$ 10,000,000
	EXCESS LIAB / CLAIMS-MADE			3386420320ES	11/1/2020	11/1/2021	AGGREGATE	$ 10,000,000
	DED / RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N						PER STATUTE / OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH)	N / A					E.L. EACH ACCIDENT	$
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$
B	Pollution Liability			ENP000458601	6/1/2020	6/1/2021	Ea. Poll Condition	1,000,000
B	Pollution Liability			ENP000458601	6/1/2020	6/1/2021	aggregate	2,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
Issued as Evidence of Insurance

CERTIFICATE HOLDER

Issued as Evidence of Insurance

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
Peter Roblin

EXCLUSIVE SOLAR USE RIGHTS AND LEASE OPTION AGREEMENT

PURCHASE
OPTION AGREEMENT

THIS OPTION AGREEMENT TO PURCHASE is entered into as of the 28th day of December 2019 (the "Effective Date") by Edmond Clermont, Richard Clermont, Armand Clermont, and Robert Clermont, hereinafter referred to as the "Owners," and CVE North America, a Delaware Corporation, hereinafter referred to as the "Operator." Owner and Operator are at times collectively referred to hereinafter as the "Parties" or individually as the "Party".

WITNESSETH:

WHEREAS, Owner is the owner of certain real estate located in Freetown on and in the vicinity of Clermont Way (the "Property"), more particularly described as 32 Middleboro Road, East Freetown, MA, recorded in Bristol County Registry of Deeds, Book 3508 and Page 28; Map 245 Lots 29 and 30 in Schedule A attached hereto and made a part hereof; and

WHEREAS, Operator is investigating the development of the Property for a solar photovoltaic electricity generation facility (the "Solar Project"); and

WHEREAS, Operator desires to obtain from the Owner an exclusive option to acquire the Property and obtain all necessary governmental approvals to construct, install, operate, remove, replace, and maintain a Solar Project (the "Solar Use Rights") upon the Property, including any necessary easement rights, and including access by, over and through "Clermont Way" (the "Purchase Option");

WHEREAS, the parties wish to reduce the terms and conditions of their agreement to writing.

WHEREAS, the parties acknowledge that there is currently a Lis Pendens issued by the Bristol County Superior Court, and that this agreement is contingent upon the removal of the Lis Pendens and any payments due to the Owners shall begin within ten (10) business days of such removal.

NOW THEREFORE, in consideration of the sum of one thousand dollars ($1,000.00) and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties hereby covenant and agree as follows:

DURATION OF THIS OFFER; This offer is valid until December 20th, 2019.

Term and Grant. Owner hereby grants to Operator, for a period of up to 26 months from the Effective Date hereof (the "Option Term"), the exclusive right and option to acquire Solar Use

Rights with respect to the Property and to have the exclusive right and option to purchase the Property, including any necessary easement rights, and including access by, over and through "Clermont Way" (the "Option"), in the manner and subject to the terms and conditions set forth herein and on Exhibit A annexed hereto. Said Option Term may be extended by mutual agreement of the Parties. Owner acknowledges that based on such grant of the Option, Operator intends to respond to one or more solicitations for solar energy and submit proposals for solar installations to be located on the Property.

1. Price. Operator will purchase the property for the Purchase Price set forth on Exhibit B annexed hereto.

2. Exercise of Option. Operator may exercise this Option as to all of the Property by providing written notice to Owner to that effect at the address specified below (the "Notice"), together with the executed Purchase and Sale Agreement (the "Purchase Agreement") in the form annexed hereto as Exhibit C, together with contract deposit specified in such Purchase Agreement.

3. Rights of Operator During Option Term. Owner understands that Operator will, at Operator's sole cost and expense, begin investigation, engineering, design and interconnect activities prior to exercising the Option and entering into the Purchase Agreement with Owner. To facilitate Operator's investigation, Owner hereby grants to Operator, its agents, and contractors, the right of ingress and egress over the Property for the purposes of evaluating the feasibility and the location of the Solar Project in order to develop, install, operate and maintain same, including all tests and studies associated therewith (the "Due Diligence"). Operator's Due Diligence activities may include, but are not limited to, the right to make all necessary municipal, governmental and utility company filings, to survey the Property, identify and flag wetlands, undertake permitting matters, geotechnical, archaeological, meteorological, insolation, and environmental studies and investigations, and any other testing that is reasonably necessary, useful, and appropriate in connection with developing and operating the Solar Project, all at Operator's sole cost and expense. If said investigation, engineering, design and interconnect activities substantially alters the value of the land the operator is to pay for the damages. Owner shall provide Operator or its agents with information about the Property, in Owner's possession and in all other ways cooperate to the extent commercially reasonable in Operator's Due Diligence activities, at no cost to Owner, including without limitation the timely execution of any reasonably necessary applications in furtherance of receiving the Solar Project approvals.

4. Purchase and Sale Agreement. The Purchase & Sales Agreement shall be executed by Owner within twelve (12) days of receipt of the Purchase Agreement executed by Operator. In addition, the Owner agrees to enter into any ancillary but necessary agreements, easements, or licenses, including access by, over and through "Clermont Way" necessary to construct, install, operate, remove, replace, and maintain the Solar Project.

5. Exclusivity. During the Option Term, Owner will not sell, contract to sell, assign, lease, encumber, or otherwise transfer the Property or any part thereof or interest therein, except subject to Operator's rights under this Option. In no event will Owner, during the Option Term, grant a license, easement, option, leasehold, or other rights to the Property, or any part thereof, to any other utility or entity seeking, directly or indirectly, to develop the Property, or any part

thereof, for solar energy conversion, or to negotiate with any other party with respect to such rights, nor permit any third party to undertake activities on the Property to evaluate the solar resources of the Property, or any part thereof. During this Option the Owner shall not enter into any agreement, or act in a manner, that could preclude the Operator from developing a Solar Project on the Property or otherwise interfere with the Operator's rights herein, as determined in the Operator's discretion.

6. Confidentiality. The terms of this Option will be held in strict confidence by the Owner and may only be shared with its own legal, financial and business advisors but not shared with any third parties including other developers, investors or brokers.

7. Binding Effect. This Option is binding upon the respective heirs, successors, and assigns of the Parties.

8. Owner's Authority. Owner is the sole owner of the Property and has the unrestricted right and authority to execute this Option and to grant to Operator the rights granted hereunder, except for the Lis Pendens previously known by to the Operator, as described in Exhibit A. Each person signing this Option on behalf of Owner is authorized to do so, and all persons or entities having any ownership interest in the Property (including spouses) are signing this Option as Owner.

9. Governing Law. This Option shall be governed by the laws of the State and County in which the Property is located, without regard to conflict of laws principles.

10. Assignment. Operator may freely assign this Option and any of its rights, responsibilities, and liabilities thereto to any party, with or without notice to Owner.

11. Possession. Possession of the Property in the same condition as of the Effective Date of this Agreement is to be given upon transfer of title, free of all tenants, personal property and encumbrances not specifically accepted in this Agreement. Seller shall neither cut nor remove forest products, nor extract or remove sand, gravel, or other natural resources from the Property after the Effective Date of this Agreement without the prior written consent of Operator.

12. Notices. Notices required to be given hereunder shall be in writing (including email) and delivered to the following addresses (as may be updated from time to time by the parties). Such notices shall be effective on the date such notice is posted or received by electronic mail.

13. [redacted]

Operator
CVE North America
Thibaut Delespaul
Email: Thibaut.delespaul@cvegroup.com

Owner
Edmond Clermont, Richard Clermont, Armand Clermont, and Robert Clermont
Via their broker/representative:

Attorney Christopher Markey
Markey & Gauvin
555 Pleasant Street, Suite 5A
New Bedford, Massachusetts 02740
(508) 717-0284
(774) 324-8238
chris@markeygauvinlaw.com

and

Broker:
Abby Clermont
Beautiful Day Real Estate LLC
234 Stafford Rd
Fall River, MA 02721
508-491-6466
Email: abbyclermont123@gmail.com or abby@beautifuldayre.com

14. Memorandum of Option. Simultaneously with the execution of this Option Agreement, Owner and Operator shall execute a Memorandum of Option in the form annexed hereto as Exhibit D. From and after the date that Operator makes its first Option Payment (as defined in Exhibit A), Operator shall have the right to record the Memorandum of Option at its sole cost and expense.

15. **ENTIRE AGREEMENT**. THIS OPTION, INCLUDING ATTACHMENTS, CONTAINS THE ENTIRE AND FINAL UNDERSTANDING OF THE PARTIES AND SUPERSEDES ALL PRIOR AGREEMENTS AND UNDERSTANDINGS BETWEEN THE PARTIES RELATED TO THE SUBJECT MATTER OF THIS OPTION.

IN WITNESS WHEREOF, Owner and Operator have executed this Option on the date below.

OPERATOR

CVE NORTH AMERICA

Name: Thibaut Delespaul
Title: President

Date: December 20, 2019

IN WITNESS WHEREOF, Owner and Operator have executed this Option on the date below.

OWNERS

Edmond J. Clermont
Name: Edmond Clermont

Date: 12/28/2019 08:22 PM EST

Title: ______

Richard P Clermont
Name: Richard Clermont

Date: 12/29/2019 07:07 PM EST

Title: ______

Armand R Clermont
Name: Armand Clermont

Date: 12/28/2019 06:15 PM EST

Title: ______

Robert E Clermont
Name: Robert Clermont

Date: 12/29/2019 09:19 AM EST

Title: ______

UTILITY NOTIFICATION

Freetown, MA, 02717

Hello,

Eversource has reviewed the application package sent for the proposed distributed generation project and has deemed the application complete. Eversource will now send the application package to Engineering to begin the screening process.

Should you have any questions during this process, please feel free to contact your Account Executive Directly, Melanie Khederian

Service Request Summary

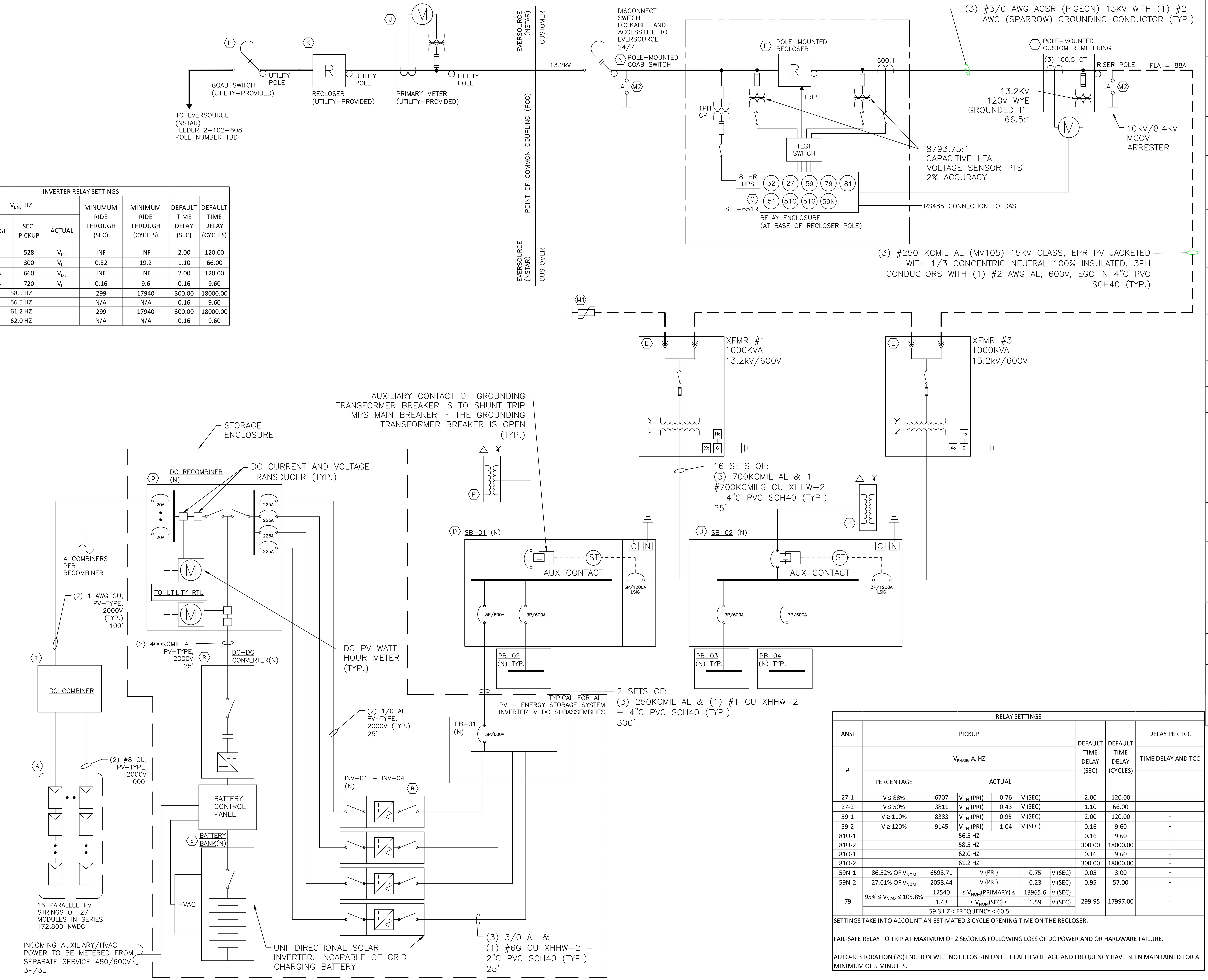
Please review the information in this section for accuracy. The customer of record, listed here, is responsible for all energy use charges. For your protection, we require confirmation of the account information by the customer of record prior to energizing your new equipment.

Eversource Work Order Number: **2384761**
Eversource Energy Account Number: **3037-720-0016**
Customer of Record: **CVE North America, Inc**
Service Address: **0 Clermont Way, Freetown, MA, 02717**
Contact Telephone Number: **732-616-4657**
DG Type: **PV & Storage**
DG Size: **2,000 kW AC**

Thanks,

Zachary Tedford
Eversource Energy
DG Administrative Assistant Contractor
247 Station Ave, SW340
Westwood, MA 02090
zachary.tedford@eversource.com

PRELIMINARY ONE-LINE ELECTRICAL DIAGRAM



INVERTER RELAY SETTINGS

ANSI #	V_{LINE}, HZ PERCENTAGE	SEC. PICKUP	ACTUAL	MINUMUM RIDE THROUGH (SEC)	MINIMUM RIDE THROUGH (CYCLES)	DEFAULT TIME DELAY (SEC)	DEFAULT TIME DELAY (CYCLES)
27-1	V ≤ 88%	528	V_{L-L}	INF	INF	2.00	120.00
27-2	V ≤ 50%	300	V_{L-L}	0.32	19.2	1.10	66.00
59-1	V ≥ 110%	660	V_{L-L}	INF	INF	2.00	120.00
59-2	V ≥ 120%	720	V_{L-L}	0.16	9.6	0.16	9.60
81U-1	58.5 HZ			299	17940	300.00	18000.00
81U-2	56.5 HZ			N/A	N/A	0.16	9.60
81O-1	61.2 HZ			299	17940	300.00	18000.00
81O-2	62.0 HZ			N/A	N/A	0.16	9.60

RELAY SETTINGS

ANSI #	PICKUP (V_{PHASE}, A, HZ) PERCENTAGE	ACTUAL				DEFAULT TIME DELAY (SEC)	DEFAULT TIME DELAY (CYCLES)	DELAY PER TCC: TIME DELAY AND TCC
27-1	V ≤ 88%	6707	V_{L-N} (PRI)	0.76	V (SEC)	2.00	120.00	-
27-2	V ≤ 50%	3811	V_{L-N} (PRI)	0.43	V (SEC)	1.10	66.00	-
59-1	V ≥ 110%	8383	V_{L-N} (PRI)	0.95	V (SEC)	2.00	120.00	-
59-2	V ≥ 120%	9145	V_{L-N} (PRI)	1.04	V (SEC)	0.16	9.60	-
81U-1	56.5 HZ					0.16	9.60	-
81U-2	58.5 HZ					300.00	18000.00	-
81O-1	62.0 HZ					0.16	9.60	-
81O-2	61.2 HZ					300.00	18000.00	-
59N-1	86.52% OF V_{NOM}	6593.71	V (PRI)	0.75	V (SEC)	0.05	3.00	-
59N-2	27.01% OF V_{NOM}	2058.44	V (PRI)	0.23	V (SEC)	0.95	57.00	-
79	95% ≤ V_{NOM} ≤ 105.8%	12540	≤ V_{NOM}(PRIMARY) ≤	13965.6	V (SEC)	299.95	17997.00	-
		1.43	≤ V_{NOM}(SEC) ≤	1.59	V (SEC)			
	59.3 HZ < FREQUENCY < 60.5							

SETTINGS TAKE INTO ACCOUNT AN ESTIMATED 3 CYCLE OPENING TIME ON THE RECLOSER.

FAIL-SAFE RELAY TO TRIP AT MAXIMUM OF 2 SECONDS FOLLOWING LOSS OF DC POWER AND OR HARDWARE FAILURE.

AUTO-RESTORATION (79) FNCTION WILL NOT CLOSE-IN UNTIL HEALTH VOLTAGE AND FREQUENCY HAVE BEEN MAINTAINED FOR A MINIMUM OF 5 MINUTES.

CABLE LEGEND
- OVERHEAD (MV)
- UNDERGROUND (MV)
- SECONDARY (LV)
- COMMUNICATIONS

SYSTEM SUMMARY:
DC SYSTEM SIZE: 2,799.36 KW
AC SYSTEM SIZE: 2,000.00 KW
STORAGE SYSTEM SIZE: 1000KW/2224 KWH
MODULE: HANWHA Q CELLS (405W)
MODULE QUANTITY: 6,912
INVERTER: SUNGROW SG125HV
INVERTER QUANTITY: 16

ITEM	EQUIPMENT SPECIFICATIONS
A	**PHOTOVOLTAIC MODULES** COUNT: 6,912 MODULES PER STRING: 27 MANUFACTURER: HANWHA Q CELLS MODEL NUMBER: Q.PEAK DUO L-G5.2 POWER OUTPUT: 405 Vmp: 41.4VDC Voc: 49.3VDC Imp: 9.79 ADC Isc: 10.28 ADC
B	**INVERTERS** COUNT: 16 MANUFACTURER: SUNGROW MODEL NUMBER: SG125HV OUTPUT POWER: 125KW NOMINAL AC VOLTS: 600V 3W MAX AC CURRENT: 120 A NEMA RATING: 3R DIMENSIONS (W x H x D): 26.4" x 35.0" x 11.7" WEIGHT: 158.7 LBS POWER FACTOR: 1.00
D	**SWITCHBOARD** COUNT: 2 RATING: 1200A, 3ϕ, 3W, 600VAC MAIN OCPD: 1200A NEMA RATING: 3R (OUTDOOR) SHORT CIRCUIT RATING: TBD DIMENSIONS (H x W x D): TBD
E	**TRANSFORMERS** COUNT: 2 MANUFACTURER: TBD KVA RATING: 1000 KVA PRIMARY VOLTAGE: 13.2kV PRIMARY BIL RATING: 95 KV SECONDARY VOLTAGE: 600 V WYE IMPEDANCE: 5.75% X/R RATIO: 7.0 WINDING: ALUMINUM
F	**POLE-MOUNTED RECLOSER** COUNT: 1 MANUFACTURER: TAVRIDA MODEL: TBD VOLTAGE RATING: 15KV CURRENT RATING: 600A CT RATIO: 600:1 VOLTAGE SENSOR RATIO: 5046.85:1 ACCURACY: 1% BIL: 95KV
H	**PROTECTIVE RELAY** COUNT: 1 MULIT-FUNCTION RELAY: YES RELAY MANUFACTURER: SCHWEITZER ENGINEERING LABS RELAY MODEL NAME: SEL-651R CT RATIO: 600:1 VOLTAGE SENSOR RATIO: 5046.85:1 ACCURACY: 1%
I	**REVENUE GRADE PRIMARY METER** COUNT: 1 MANUFACTURER: SCHWEITZER ENGINEERING LABS MODEL NAME: SEL 735 CT RATIO: 600:5 PT RATIO: 110:1 ACCURACY: TBD METER MFR/MODEL: TBD METER PN: TBD
J	**POLE MOUNTED METER** ****PROVIDED BY EVERSOURCE**** COUNT: 1
K	**RECLOSER** ****PROVIDED BY EVERSOURCE**** COUNT: 1
L	**GOAB SWITCH** ****PROVIDED BY EVERSOURCE**** COUNT: 1
M1	**SURGE ARRESTER** COUNT: 3 MANUFACTURER: TBD MODEL NAME: TBD CAT NO: TBD VOLTAGE RATING: 15 KV MCOV RATING: 15.3 KV
M2	COUNT: 6 MANUFACTURER: TBD ELBOW ARRESTER MODEL/PN: TBD VOLTAGE RATING: 15 KV MCOV RATING: 15.3 KV
N	**POLE-MOUNTED GOAB SWITCH** COUNT: 1 MANUFACTURER: HUBBELL MODEL NAME: TYPE D7 UNITIZED SWITCHES PART NUMBER: D7HS1AAN VOLTAGE / BIL RATING: 15 KV / 95 KV
O	**TEST SWITCH** COUNT: 1 MANUFACTURER: TAVRIDA MODEL NAME: TBD NUMBERE OF POLES: TBD
P	**GROUNDING TRANSFORMER** COUNT: 1 MANUFACTURER: TBD RATING: 45 KVA IMPEDANCE: 5%
Q	**DC RECOMBINER** COUNT: 4 MANUFACTURER: SUNGROW MAX CURRENT: 344A VOLTAGE: 1500V
R	**DC-DC CONVERTER** COUNT: 4 MANUFACTURER: SUNGROW MODEL NAME: SD-250 NOMINAL POWER: 250KW
S	**BATTERY BANK** COUNT: 4 MANUFACTURER: SAMSUNG SDI BATTERY CAPACITY: 556 KWH CELL CONFIGURATION: TBD
T	**DC COMBINER** COUNT: 4 MANUFACTURER: SUNGROW MODEL NAME: SD-250 NOMINAL POWER: 250KW

REVISIONS

REV	BY	DESCRIPTION	DATE
0	MG	INTERCONNECTION APPLICATION	12/16/2019
1	MD	INTERCONNECTION RESUBMITTAL	07/31/2020
2	CT	LAYOUT UPDATE-WETLAND DELINEATIONS	01/19/2021
3	CT	SLD UPDATE-CP COMMENTS	01/29/2021

cve Changing Visions of Energy
109 W 29TH STREET, 8TH FLOOR
NEW YORK, NY 10001
CVEGROUP.COM

DRAWING ISSUE
☒ PRELIMINARY
☐ PERMITTING
☐ CONSTRUCTION
☐ AS-BUILT

PROFESSIONAL ENGINEER
RICHARD A. IVINS
MA LICENSE No. 49915

PROJECT NAME:
2.799 MW GROUND MOUNT SOLAR + STORAGE SYSTEM AT
CVE - FREETOWN CLERMONT
0 CLERMONT WAY, FREETOWN, MA 02717

PROJECT ID:
USS00061

SHEET NAME:
E1.1
SINGLE LINE DIAGRAM

PHOTOVOLTAIC ARRAY COMPONENT DOCUMENTS powered by Q.ANTUM DUO

Q.PEAK DUO L-G5.2

380-405

ENDURING HIGH PERFORMANCE

Q.ANTUM TECHNOLOGY: LOW LEVELISED COST OF ELECTRICITY

Higher yield per surface area, lower BOS costs, higher power classes, and an efficiency rate of up to 20.3%.

INNOVATIVE ALL-WEATHER TECHNOLOGY

Optimal yields, whatever the weather with excellent low-light and temperature behaviour.

ENDURING HIGH PERFORMANCE

Long-term yield security with Anti LID Technology, Anti PID Technology[1], Hot-Spot Protect and Traceable Quality Tra.Q™.

EXTREME WEATHER RATING

High-tech aluminium alloy frame, certified for high snow (5400 Pa) and wind loads (2400 Pa).

A RELIABLE INVESTMENT

Inclusive 12-year product warranty and 25-year linear performance warranty[2].

STATE OF THE ART MODULE TECHNOLOGY

Q.ANTUM DUO combines cutting edge cell separation and innovative wiring with Q.ANTUM Technology.

[1] APT test conditions according to IEC/TS 62804-1:2015, method B (−1500 V, 168 h)

[2] See data sheet on rear for further information.

THE IDEAL SOLUTION FOR:

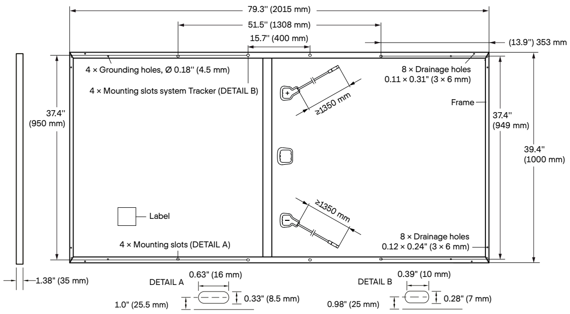
- Rooftop arrays on commercial / industrial buildings
- Ground-mounted solar power plants

Engineered in Germany

Q CELLS

MECHANICAL SPECIFICATION

Format	79.3 in × 39.4 in × 1.38 in (including frame) (2015 mm × 1000 mm × 35 mm)
Weight	51.8 lbs (23.5 kg)
Front Cover	0.13 in (3.2 mm) thermally pre-stressed glass with anti-reflection technology
Back Cover	Composite film
Frame	Anodized aluminum
Cell	6 × 24 monocrystalline Q.ANTUM solar half cells
Junction Box	2.09-3.98 × 1.26-2.36 × 0.59-0.71 in (53-101 × 32-60 × 15-18 mm), Protection class IP67, with bypass diodes
Cable	4 mm² Solar cable; (+) ≥53.1 in (1350 mm), (−) ≥53.1 in (1350 mm)
Connector	Stäubli MC4, Stäubli MC4-Evo2, Amphenol UTX, Renhe 05-8, Tonglin TL-Cable01S-F; IP68 or Friends PV2e; IP67

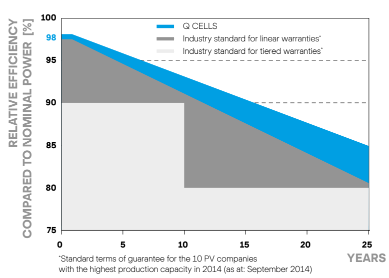


ELECTRICAL CHARACTERISTICS

POWER CLASS				380	385	390	395	400	405
MINIMUM PERFORMANCE AT STANDARD TEST CONDITIONS, STC[1] (POWER TOLERANCE +5 W / −0 W)									
Minimum	Power at MPP[1]	P_{MPP}	[W]	380	385	390	395	400	405
	Short Circuit Current[1]	I_{SC}	[A]	10.05	10.10	10.14	10.19	10.24	10.28
	Open Circuit Voltage[1]	V_{OC}	[V]	47.95	48.21	48.48	48.74	49.00	49.26
	Current at MPP	I_{MPP}	[A]	9.57	9.61	9.66	9.70	9.75	9.79
	Voltage at MPP	V_{MPP}	[V]	39.71	40.05	40.38	40.71	41.04	41.36
	Efficiency[1]	η	[%]	≥18.9	≥19.1	≥19.4	≥19.6	≥19.9	≥20.1
MINIMUM PERFORMANCE AT NORMAL OPERATING CONDITIONS, NMOT[2]									
Minimum	Power at MPP	P_{MPP}	[W]	284.4	288.2	291.9	295.6	299.4	303.1
	Short Circuit Current	I_{SC}	[A]	8.10	8.14	8.17	8.21	8.25	8.28
	Open Circuit Voltage	V_{OC}	[V]	45.21	45.46	45.71	45.96	46.21	46.45
	Current at MPP	I_{MPP}	[A]	7.53	7.57	7.60	7.64	7.67	7.71
	Voltage at MPP	V_{MPP}	[V]	37.77	38.08	38.40	38.71	39.02	39.33

[1]Measurement tolerances P_{MPP} ±3%; I_{SC}; V_{OC} ±5% at STC: 1000 W/m², 25±2 °C, AM 1.5 G according to IEC 60904-3 • [2]800 W/m², NMOT, spectrum AM 1.5 G

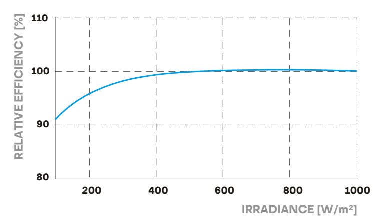
Q CELLS PERFORMANCE WARRANTY



At least 98% of nominal power during first year. Thereafter max. 0.54% degradation per year. At least 93.1% of nominal power up to 10 years. At least 85% of nominal power up to 25 years.

All data within measurement tolerances. Full warranties in accordance with the warranty terms of the Q CELLS sales organisation of your respective country.

PERFORMANCE AT LOW IRRADIANCE



Typical module performance under low irradiance conditions in comparison to STC conditions (25 °C, 1000 W/m²)

TEMPERATURE COEFFICIENTS

Temperature Coefficient of I_{SC}	α	[% / K]	+0.04	Temperature Coefficient of V_{OC}	β	[% / K]	−0.27
Temperature Coefficient of P_{MPP}	γ	[% / K]	−0.36	Normal Module Operating Temperature	NMOT	[°F]	109±5.4 (43±3 °C)

PROPERTIES FOR SYSTEM DESIGN

Maximum System Voltage V_{SYS}	[V]	1500 (IEC) / 1500 (UL)	Safety Class	II
Maximum Series Fuse Rating	[A DC]	20	Fire Rating	C / TYPE 1
Max. Design Load, Push / Pull[3]	[lbs / ft²]	75 (3600 Pa) / 33 (1600 Pa)	Permitted Module Temperature on Continuous Duty	−40 °F up to +185 °F (−40 °C up to +85 °C)
Max. Test Load, Push / Pull[3]	[lbs / ft²]	113 (5400 Pa) / 50 (2400 Pa)		

[3] See Installation Manual

QUALIFICATIONS AND CERTIFICATES

UL 1703, CE-compliant, IEC 61215:2016, IEC 61730:2016, Application Class II, U.S. Patent No. 9,893,215 (solar cells)

C Certified US UL 1703 (254141)

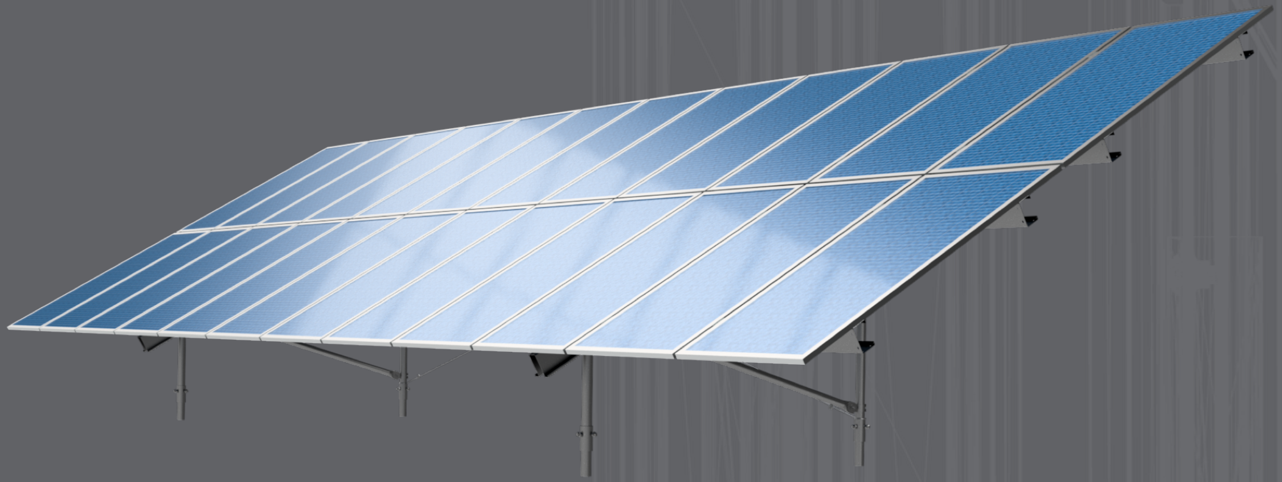
PACKAGING INFORMATION

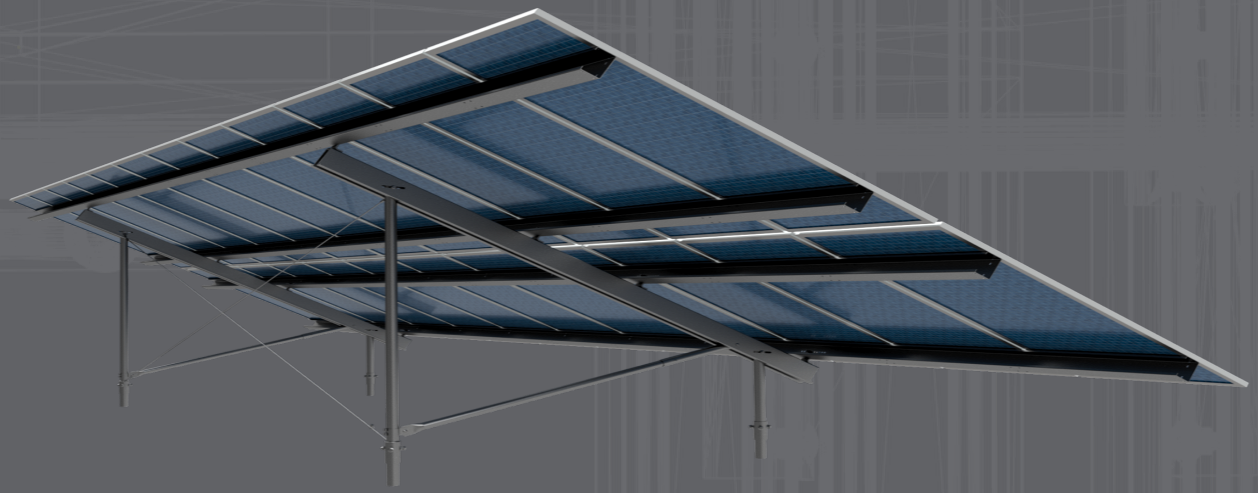
Number of Modules per Pallet	29
Number of Pallets per 53' Trailer	27
Number of Pallets per 40' HC-Container	22
Pallet Dimensions (L × W × H)	81.9 × 45.3 × 46.9 in (2080 × 1150 × 1190 mm)
Pallet Weight	1635 lbs (742 kg)

Note: Installation instructions must be followed. See the installation and operating manual or contact our technical service department for further information on approved installation and use of this product.

Hanwha Q CELLS America Inc.
400 Spectrum Center Drive, Suite 1400, Irvine, CA 92618, USA | **TEL** +1 949 748-5996 | **EMAIL** inquiry@us.q-cells.com | **WEB** www.q-cells.com/na

TERRASMART





(239) 362-0211 | WWW.TERRASMART.COM

GLIDE - TGP
Fixed-Tilt Ground Mount

OVERVIEW

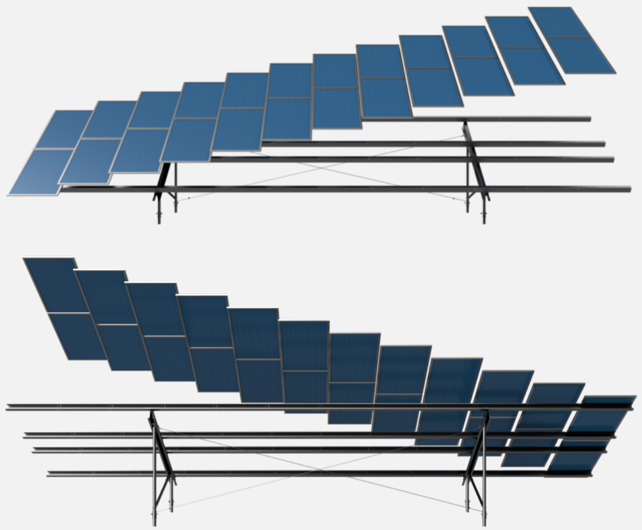
GLIDE Portrait (TGP) is TerraSmart's next generation fixed-tilt ground mount racking solution. TGP is the culmination of ten years and over 3 gigawatts of installed-capacity experience in engineering, manufacturing and construction. As a result, GLIDE is currently the most economical racking system in TerraSmart's fixed-tilt ground mount racking portfolio. Leveraging the benefits of TerraSmart's widely deployed proprietary ground screw foundation, TGP is designed to work in any soil condition.

TerraSmart's state-of-the-art surveying, rock drilling and installation equipment removes project risks and provides post-installation documentation for increased project bankability. All of these benefits improve upon TerraSmart's industry-leading construction efficiency and raise the bar by offering customers increased install efficiency, reduced labor hours and tenders significant savings in material costs.

START SMART. BUILD SMART.

SPECS

Specifications Member Material	ASTM AIOII Cold Rolled Steel, Hot Dip Galvanized to ASTM A653 (G90 min) ASTM A 500 Hollow Structural Steel, Hot Dip Galvanized to ASTM A123 (3.0 mils min)
Hardware Material	316 Stainless Steel for Module Mounting Hardware Carbon Steel Alloy, Magni Coated to ASTM F2833 for all Structural Hardware
Foundation Options	Ground Screw Portrait
Module Orientation	Portrait
Module Mounting	Bottom Mount Integrated Electrical Bonding
Tilt Angle	5 to 40 degrees
Wire Management	Incorporated in Structure – NEC Compliant
Configuration	Portrait: Up to 2 high x up to 12 wide
Slopes	East or West facing, up to 30%, north or south facing, up to 36%
Load Capacities	Project Specific; Up to 170 MPH wind speed and 100 PSF Ground Snow Load
Certifications	UL 2703, Edition 1; CPP Wind Tunnel Tested
Warranty	20 - year limited warranty



FAST
- Exponentially Less Hardware
- Integrated Electrical Bonding
- Included Wire Managment

COMPLIANT
- UL 2703, Edition 1 Listed
- NEC Compliant
- Wind Tunnel Tested

VERSATILE
- Numerous Configurations
- Adapts to Steep Slopes
- Accommodates Arduous Soils

LIGHT
- Lighter / Stiffer Components
- Less Freight Costs

(239) 362-0211 | WWW.TERRASMART.COM

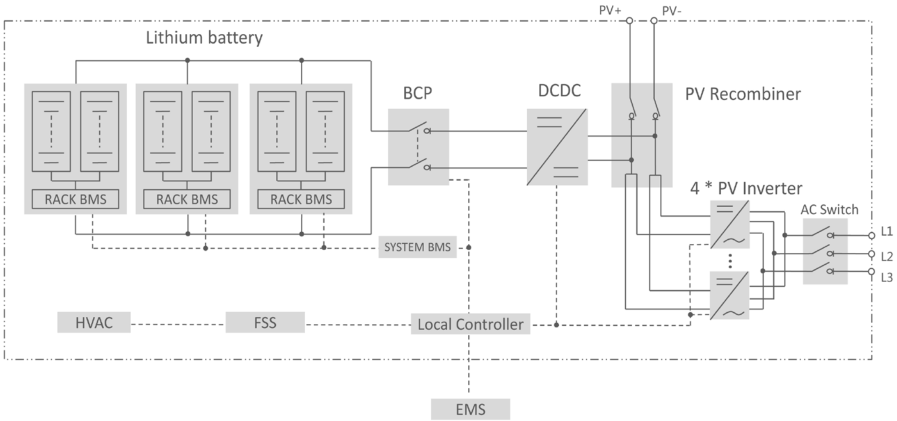
ST556KWH-D250HV +4xSG125HV

Storage System

SYSTEM FEATURES

- Fully integrated 1500V DC coupled PV+ESS system with “one stop shop”
- Intelligent MPPT-Charging control algorithm enable the high-efficient operation

CIRCUIT DIAGRAM



System Type	ST556KWH-D250HV+4xSG125HV
PV Data	
Max PV input voltage	1,500 V
MPPT voltage range at nominal power	860 ~ 1,250 V
Number of DC inputs	5
Max. PV input current	1,250 A
DCDC Data	
Working voltage range	500 ~ 1,500 V
Nominal power	250 KW
Max. current	344 A
Battery Data	
Cell type	Samsung SDI Mega E3, 3.68 V / 100 Ah
Configuration of system	2P252S*3
Battery capacity (BOL)	556 kWh
Battery voltage range	806.4 ~1,045.8 V
AC Data	
AC output power	500kVA @ 50 ℃
Max. AC output current	480 A
Nominal AC voltage	3 / PE, 600 V
AC voltage range	480 ~ 690 V
Nominal grid frequency / Grid frequency range	60 Hz / 55 ~ 65 Hz
Power factor at nominal power / Adjustable power factor	> 0.99 / 0.8 leading ~ 0.8 lagging
Feed-in phases / connection phases	3/3
General Data	
Dimensions (W * H * D)	6,058 * 2,896 * 2,438 mm / 238.5" * 114.0" * 96.0"
Weight (with / without battery)	11.0 T / 7.0 T 24,250 lbs / 15,432 lbs
Degree of protection	IP 54 / NEMA 3R
Operating temperature range	-30 to 50 ℃ / -22 to 122 ℉
Relative humidity	0 ~ 95 % (non-condensing)
Max. working altitude	2,000 m / 6,562 ft
Cooling concept of battery chamber	Heating, Ventilation and Air Conditioning
Fire suppression system of battery unit	FM-200 extinguishment system
Communication interfaces	RS485, Ethernet
Communication protocols	Modbus RTU, Modbus TCP
Compliance	UL 9540, UL 9540A

SG125HV

String Inverter for 1500 Vdc System

SUNGROW
Clean power for all

HIGH YIELD

- Patented five-level topology, max. efficiency 98.9 %, European efficiency 98.7 %, CEC efficiency 98.5 %
- Full power operation without derating at 50 ℃
- Patented anti-PID function

EASY O&M

- Virtual central solution, easy for O&M
- Compact design and light weight for easy installation

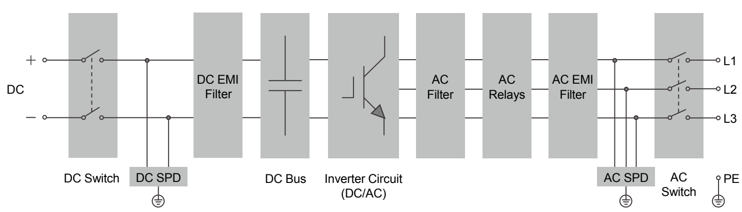
SAVED INVESTMENT

- DC 1500V,AC 600V, low system initial investment
- 1 to 5MW power block design for lower AC transformer and labor cost
- Max.DC/AC ratio up to 1.5

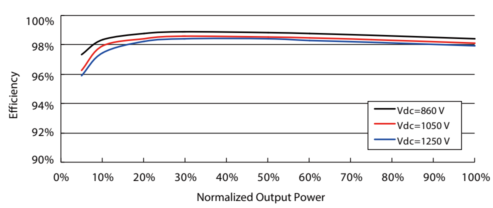
GRID SUPPORT

- Compliance with both IEC and UL safety,EMC and grid support regulations
- Low/High voltage ride through(L/HVRT)
- Active & reactive power control and power ramp rate control

CIRCUIT DIAGRAM



EFFICIENCY CURVE



Type designation	SG125HV
Input (DC)	
Max. PV input voltage	1500 V
Min. PV input voltage / Start-up input voltage	860 V / 920 V
Nominal PV input voltage	1050 V
MPP voltage range	860 – 1450 V
MPP voltage range for nominal power	860 – 1250 V
No. of independent MPP inputs	1
No. of DC inputs	1
Max. PV input current	148 A
Max. DC short-circuit current	250 A
Output (AC)	
AC output power	125 kVA @ 50 ℃
Max. AC output current	120 A
Nominal AC voltage	3 / PE, 600 V
AC voltage range	480 – 690 V
Nominal grid frequency / Grid frequency range	50 Hz / 45 – 55 Hz, 60 Hz / 55 – 65 Hz
THD	< 3 % (at nominal power)
DC current injection	< 0.5 % In
Power factor at nominal power / Adjustable power factor	> 0.99 / 0.8 leading - 0.8 lagging
Feed-in phases / connection phases	3 / 3
Efficiency	
Max. efficiency / European efficiency	98.9% / 98.7%
CEC efficiency	98.5%
Protection	
DC reverse connection protection	Yes
AC short-circuit protection	Yes
Leakage current protection	Yes
Grid monitoring	Yes
DC switch	Yes
AC switch	Yes
Q at night function	No
Anti-PID function	Yes
Overvoltage protection	DC Type II / AC Type II
General Data	
Dimensions (W*H*D)	670*902*296 mm 26.4''*35.5''*11.7''
Weight	76 kg 167.5 lb
Isolation method	Transformerless
Degree of protection	IP 65 NEMA 4X
Night power consumption	< 4 W
Operating ambient temperature range	-30 to 60 ℃ (> 50 ℃ derating) -22 to 140 ℉ (> 122 ℉ derating)
Allowable relative humidity range (non-condensing)	0 – 100 %
Cooling method	Smart forced air cooling
Max. operating altitude	4000 m (> 3000 m derating) 13123 ft (> 9843 ft derating)
Display / Communication	LED, Bluetooth+APP / RS485
DC connection type	OT or DT terminal (Max. 185 mm² 350 Kcmil)
AC connection type	OT or DT terminal (Max. 185 mm² 350 Kcmil)
Compliance	UL1741, UL1741SA, IEEE1547, IEEE1547.1, CSA C22.2 107.1-01-2001, FCC Part15 Sub-part B Class A Limits, California Rule 21, IEC 62109-1/-2, IEC 61000-6-2/-4, IEC 61727, IEC62116, BDEW, EN50549,VDE-AR-N 4110:2018, VDE-AR-N 4120:2018, UNE 206007-1:2013, P.O.12.3, UTE C15-712-1:2013, CEI 0-16:2017, IEC 61683, PEA, NTCO
Grid Support	LVRT, HVRT, ZVRT, active & reactive power regulation, PF control, soft start/stop

POLLINATOR FRIENDLY SOLAR DESCRIPTION AND PROPOSED SEED MIX

POLLINATOR FRIENDLY SOLAR ARRAY

This solar installation benefits wildlife, agriculture, and climate

Why are pollinators important

Pollinators are animals including bees, butterflies and moths that transfer pollen from one plant to another, ensuring reproduction. They are critically important to ecosystems, as well as our food supply and agricultural economy.
Over 80% of flowering plants on earth depend upon insect-mediated pollination. In fact, the survival of most plant and animal species on the planet depends upon native pollination ecosystems.

Food
Pollinators provide us with fruits, vegetables, nuts and more

Economy
Pollinators contribute to local food systems and agricultural economies by increasing yields and quality of crops

Ecosystems
Pollinators support healthy ecosystems that clean the air, stabilize soils, protect from severe weather, and support other wildlife

Benefits of pollinator friendly solar

It's good for native wildlife
It provides a habitat for pollinators and other wildlife

It's cost effective
It requires less maintenance and mowing

It's prettier
It makes the area visually appealing to neighbors and visitors.
Depending on the season and on the stage of seeding, you may not see flowers yet.

How we do it:

- We plant native wildflowers with high value for pollinators (see some examples on the right)
- We limit the use of pesticide and insecticide
- We install cavity nesting habitat for bees
- We leave a gap at the bottom of the fence for wildlife passage


Golden Alexanders - *Zizia Aurea*


Butterfly weed - *Asclepias tuberosa*


Little Bluestem - *Schizachyrium Scoparium*


Yellow Wild Indigo - *Baptisia Tinctoria*


Gray Goldenrod - *Solidago Nemoralis*

Backed by Science: This site is Pollinator-Friendly certified

This solar facility has achieved Silver certification through the UMass Clean Energy Extension Pollinator-Friendly Certification Program for Solar PV Arrays. All plants have been carefully selected by a professional botanist to ensure they support pollinators. Management activities – including removal of invasive plants, limited mowing and trimming, and avoidance of insecticides – all contribute to keeping this site pollinator-friendly.

Want to learn more about helping pollinators in your community?
Contact UMass Clean Energy Extension (413-545-8510, ag.umass.edu/clean-energy).

UMass Clean Energy Extension
Research & Outreach

cve North America
Changing Visions of Energy

SEED MIX NAME: Pollinator Sun Mix

Location to be used: Array (all areas not under solar panels) and perimeter

Seeding rate: 110 PLS/sq.ft

Common Name	Scientific Name	Percentage of Mix	Seed Geographic Origin	MA Status	Approx. Bloom Period	Soil Requirements	Specialist Bee Host?	Rare Lepidoptera Host?
yarrow	*Achillea millefolium*	2.06	Midwest	fairly widespread	July-Oct	medium, moist	N/A	N/A
upland bent grass	*Agrostis perennans*	2.11	New York	widespread	N/A	medium, moist, dry	N/A	Yes****
pearly everlasting	*Anaphalis margaritaceae*	3.42	Minnesota	widespread	July-Aug	dry	N/A	N/A
broomsedge bluestem	*Andropogon virginicus*	2.17	Wisconsin	fairly widespread	N/A	dry, medium	N/A	Yes
pussytoes	*Antennaria plantaginifolia*	4.08	Minnesota	widespread	April-June	dry, medium	N/A	N/A
butterfly weed	*Asclepias tuberosa*	2.02	Upper Midwest	fairly widespread	June-Aug	dry	N/A	N/A
yellow wild indigo	*Baptisia tinctoria*	1.00	West Virginia	widespread	June-Aug	dry	N/A	Yes
plains oval sedge	*Carex brevior*	2.01	Minnesota	widespread	N/A	dry, medium, moist	N/A	N/A
partridge sensitive-pea	*Chamaecrista fasciculata*	2.12	Minnesota/Iowa	fairly widespread	June-Aug	dry, medium	N/A	Yes*****
prairie cinquefoil	*Drymocallis (Potentilla) arguta*	4.10	Iowa	fairly widespread	June-Sept	medium, dry	Yes*	N/A
poverty oat grass	*Danthonia spicata*	2.62	Minnesota	widespread	N/A	medium, dry	N/A	Yes******
purple lovegrass	*Eragrostis spectabilis*	2.12	Illinois	widespread	N/A	dry	N/A	N/A
spotted St. John's-wort	*Hypericum punctatum*	7.60	Illinois	widespread	July-Aug	medium, dry	N/A	N/A
slender bush-clover	*Lespedeza virginica*	3.14	Illinois	fairly widespread	Aug	dry	N/A	Yes*******
bladder-pod lobelia	*Lobelia inflata*	4.35	Wisconsin	widespread	July-Oct	medium	N/A	N/A
foxglove beardtongue	*Penstemon digitalis*	6.48	Wisconsin	widespread	April-June	medium, dry	N/A	N/A
slender mountain mint	*Pycnanthemum tenuifolium*	4.95	Illinois	fairly widespread	July-Sept	dry	N/A	N/A
Virginia mountain mint	*Pycnanthemum virginianum*	5.48	Illinois	fairly widespread	July-Aug	medium, dry	N/A	N/A
black-eyed Susan	*Rudbeckia hirta*	5.32	Iowa	widespread	June-Sept	medium, dry	N/A	N/A
little bluestem	*Schizachyrium scoparium*	12.58	Wisconsin	widespread	N/A	dry	N/A	Yes
gray goldenrod	*Solidago nemoralis*	8.01	Iowa	widespread	Aug-Oct	medium	Yes**	N/A
heart-leaved American-	*Symphyotrichum cordifolium*	2.18	Wisconsin	widespread	Aug-Oct	medium	Yes**	N/A
heath American-aster	*Symphyotrichum ericoides*	2.14	Wisconsin	widespread	Sept-Oct	dry	Yes***	N/A
calico American-aster	*Symphyotrichum lateriflorum*	4.47	Minnesota	widespread	Aug-Sept	medium, dry	Yes***	N/A
golden Alexanders	*Zizia aurea*	3.46	Illinois	widespread	May-July	dry, medium	Yes	N/A
		100						

NOTES:

*Andrena (Micrandrena) melanochroa. https://jarrodfowler.com/specialist_bees.html

**The most recurrent host plant genera associations among pollen specialist bee species include Solidago L. (37 spp.). Specialist bees include: Andrena (Callandrena s.l.) aliciae, Andrena (Callandrena s.l.) asteris, Andrena (Cnemidandrena) canadensis, Perdita (Perdita) octomaculata, Pseudopanurgus aestivalis. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html

***The most recurrent host plant genera associations among pollen specialist bee species include Symphyotrichum Nees (32 spp.). Specialist bees include: Andrena (Cnemidandrena) hirticincta, Pseudopanurgus aestivalis, Melissodes (Eumelissodes) dentiventris, Colletes americanus, Dianthidium (Dianthidium) simile. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html

****Indian Skipper (Hesperia sassacus) and Leonard's Skipper (Hesperia leonardus). References: https://www.butterfliesofmassachusetts.net/conservation-species.htm, https://www.butterfliesofmassachusetts.net/indian.htm, https://www.butterfliesofmassachusetts.net/Leonards.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

*****Little Yellow (Eurema lisa). In both Atlas (1986-90) and MBC (2000-2007) records, Little Yellow ranks as Rare or Very Rare. References: https://www.butterfliesofmassachusetts.net/little-yellow.htm, https://www.butterfliesofmassachusetts.net/methods.htm#Table%205.%20Relative%20Abundance%20MBC/Atlas%20Comparisons, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

******Indian Skipper (Hesperia sassacus) and Leonard's Skipper (Hesperia leonardus). https://www.butterfliesofmassachusetts.net/Leonards.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

*******Hoary Edge (Achalarus lyciades). Hoary Edge's caterpillar host plants are mainly various tick-trefoils, especially showy tick-trefoil (Desmodium canadense), which is quite common in our area, but also bush clovers (Lespedeza spp.) and other legumes. References: http://www.butterfliesofmassachusetts.net/hoary-edge.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

Attachment A2
Seed Mix Table

SEED MIX NAME: Pollinator Shade Mix
Location to be used: Array (under solar panels)

Seeding rate: 110 PLS/sq.ft

Common Name	Scientific Name	Percentage of Mix	Seed Geographic Origin	MA Status	Approx. Bloom Period	Soil Requirements	Specialist Bee Host?	Rare Lepidoptera Host?
white snakeroot	*Ageratina altissima*	2.97	Minnesota	fairly widespread	July-Oct	medium, moist	N/A	N/A
upland bent grass	*Agrostis perennans*	3.29	New York	widespread	N/A	medium, moist, dry	N/A	Yes****
broomsedge bluestem	*Andropogon virginicus*	3.37	Wisconsin	fairly widespread	N/A	dry, medium	N/A	Yes
pussytoes	*Antennaria plantaginifolia*	3.88	Minnesota	widespread	April-June	dry, medium	N/A	N/A
red columbine	*Aquilegia canadensis*	4.29	Iowa	widespread	May-July	moist, medium, dry	N/A	N/A
partridge sensitive-pea	*Chamaecrista fasciculata*	2.08	Minnesota/Iowa	fairly widespread	June-Aug	dry, medium	N/A	Yes*****
prairie cinquefoil	*Drymocallis (Potentilla) arguta*	3.11	Iowa	fairly widespread	June-Sept	medium, dry	Yes*	N/A
purple lovegrass	*Eragrostis spectabilis*	3.68	Illinois	widespread	N/A	dry	N/A	N/A
spotted St. John's-wort	*Hypericum punctatum*	6.54	Illinois	widespread	July-Aug	medium, dry	N/A	N/A
slender bush-clover	*Lespedeza virginica*	2.16	Illinois	fairly widespread	Aug	dry	N/A	Yes******
bladder-pod lobelia	*Lobelia inflata*	4.50	Wisconsin	widespread	July-Oct	medium	N/A	N/A
foxglove beardtongue	*Penstemon digitalis*	4.10	Wisconsin	widespread	April-June	medium, dry	N/A	N/A
slender mountain mint	*Pycnanthemum tenuifolium*	5.33	Illinois	fairly widespread	July-Sept	dry	N/A	N/A
black-eyed Susan	*Rudbeckia hirta*	6.22	Iowa	widespread	June-Sept	medium, dry	N/A	N/A
little bluestem	*Schizachyrium scoparium*	13.30	Wisconsin	widespread	N/A	dry	N/A	Yes
early goldenrod	*Solidago juncea*	4.09	Illinois	widespread	July-Sept	dry	Yes**	N/A
gray goldenrod	*Solidago nemoralis*	8.11	Iowa	widespread	Aug-Oct	medium	Yes**	N/A
sweet goldenrod	*Solidago odora*	1.13	Wisconsin	widespread	Aug-Oct	medium	Yes**	N/A
heart-leaved American-	*Symphyotrichum cordifolium*	2.21	Wisconsin	widespread	Sept-Oct	medium, dry	Yes***	N/A
heath American-aster	*Symphyotrichum ericoides*	2.16	Wisconsin	widespread	Sept-Oct	dry	Yes***	N/A
calico American-aster	*Symphyotrichum lateriflorum*	7.05	Minnesota	widespread	Aug-Sept	medium, dry	Yes***	N/A
Ohio spiderwort	*Tradescantia ohiensis*	2.71	Illinois	fairly widespread	July-Sept	medium, dry	N/A	N/A
golden Alexanders	*Zizia aurea*	3.72	Illinois	widespread	May-July	dry, medium	Yes	N/A
		100						

NOTES:
*Andrena (Micrandrena) melanochroa. https://jarrodfowler.com/specialist_bees.html
**The most recurrent host plant genera associations among pollen specialist bee species include Solidago L. (37 spp.). Specialist bees include: Andrena (Callandrena s.l.) aliciae, Andrena (Callandrena s.l.) asteris, Andrena (Cnemidandrena) canadensis, Perdita (Perdita) octomaculata, Pseudopanurgus aestivalis. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html
***The most recurrent host plant genera associations among pollen specialist bee species include Symphyotrichum Nees (32 spp.). Specialist bees include: Andrena (Cnemidandrena) hirticincta, Pseudopanurgus aestivalis, Melissodes (Eumelissodes) dentiventris, Colletes americanus, Dianthidium (Dianthidium) simile. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html
****Indian Skipper (Hesperia sassacus) and Leonard's Skipper (Hesperia leonardus). References: https://www.butterfliesofmassachusetts.net/conservation-species.htm, https://www.butterfliesofmassachusetts.net/indian.htm, https://www.butterfliesofmassachusetts.net/Leonards.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.
*****Little Yellow (Eurema lisa). In both Atlas (1986-90) and MBC (2000-2007) records, Little Yellow ranks as Rare or Very Rare. References: https://www.butterfliesofmassachusetts.net/little-yellow.htm, https://www.butterfliesofmassachusetts.net/methods.htm#Table%205.%20Relative%20Abundance%20MBC/Atlas%20Comparisons, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.
******Hoary Edge (Achalarus lyciades). Hoary Edge's caterpillar host plants are mainly various tick-trefoils, especially showy tick-trefoil (Desmodium canadense), which is quite common in our area, but also bush clovers (Lespedeza spp.) and other legumes. References: http://www.butterfliesofmassachusetts.net/hoary-edge.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

SEED MIX NAME: Basin Mix

Location to be used: Stormwater management basins within fenceline

Seeding rate: 110 PLS/sq.ft

Common Name	Scientific Name	Percentage by Count	Percentage by Weight	Seed Geographic Origin	MA Status	Approx. Bloom Period	Soil Requirements	Specialist Bee Host?	Rare Lepidoptera Host?
southern water-plantain	*Alisma subcordatum*	2.48	10.70	Minnesota	widespread	June-Sept	wet	N/A	N/A
nodding beggar-ticks	*Bidens cernua*	0.65	8.02	Iowa	widespread	Aug-Oct	wet	Yes*	N/A
bearded sedge	*Carex comosa*	0.62	5.35	Illinois	widespread	N/A	wet	N/A	N/A
hop sedge	*Carex lupulina*	0.07	5.35	Pennsylvania	widespread	N/A	wet, moist	N/A	N/A
lurid sedge	*Carex lurida*	0.25	5.35	Illinois	widespread	N/A	moist, wet	N/A	N/A
fox sedge	*Carex vulpinoidea*	6.19	16.04	Illinois	widespread	N/A	moist, wet	N/A	N/A
tall white-aster	*Doellingeria umbellata*	1.38	5.35	Illinois	widespread	July-Oct	medium, moist, wet	N/A	Yes
boneset	*Eupatorium perfoliatum*	3.30	5.35	Minnesota	widespread	July-Sept	medium, moist, wet	N/A	N/A
grass-leaved goldenrod	*Euthamia (Solidago) graminifolia*	5.06	3.74	Minnesota	widespread	July-Sept	medium, moist, wet	Yes	N/A
Hollow Joe-Pye weed	*Eutrochium fistulosum*	1.61	5.35	Minnesota	widespread	July-Sept	moist, wet	Yes**	N/A
soft rush	*Juncus effusus*	20.65	5.35	Wisconsin	widespread	N/A	moist, wet	N/A	N/A
ditch-stonecrop	*Penthorum sedoides*	26.84	5.35	Illinois	fairly widespread	June-Sept	moist, wet	N/A	N/A
dark-green bulrush	*Scirpus atrovirens*	9.50	5.35	Iowa	fairly widespread	N/A	wet	N/A	N/A
woolgrass	*Scirpus cyperinus*	17.55	2.67	Wisconsin	widespread	N/A	wet	N/A	Yes***
blue vervain	*Verbena hastata*	3.84	10.70	New Jersey	widespread	July-Sept	medium, moist, wet	Yes	N/A
	Total percentage	100	100						

NOTES:

*The most recurrent host plant genera associations among pollen specialist bee species include Bidens L. (12 ssp.). Specialist bees include: Andrena (Callandrena s.l.) aliciae, Melissodes (Eumelissodes) dentiventris and Colletes compactus. Reference: https://jarrodfowler.com/specialist_bees.html

**Reference: https://jarrodfowler.com/host_plants.html

***Dion Skipper (Euphyes dion). Reference: R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

SEED MIX NAME: Berm Mix

Location to be used: Berms within the fenceline and beneath vegetative screen

Seeding rate: 110 PLS/sq.ft

Common Name	Scientific Name	Percentage of Mix	Seed Geographic Origin	MA Status	Approx. Bloom Period	Soil Requirements	Specialist Bee Host?	Rare Lepidoptera Host?
broomsedge bluestem	*Andropogon virginicus*	15.20	Missouri	fairly widespread	N/A	dry, medium	N/A	Yes
butterfly weed	*Asclepias tuberosa*	0.27	MIchigan	fairly widespread	June-Aug	dry	N/A	N/A
partridge sensitive-pea	*Chamaecrista fasciculata*	1.35	Minnesota	fairly widespread	June-Aug	dry, medium	N/A	Yes***
poverty oat grass	*Danthonia spicata*	3.11	Minnesota	widespread	N/A	medium, dry	N/A	Yes****
purple lovegrass	*Eragrostis spectabilis*	26.16	Minnesota	widespread	N/A	dry	N/A	N/A
black-eyed Susan	*Rudbeckia hirta*	11.46	Iowa	widespread	June-Sept	medium, dry	N/A	N/A
hairy panic grass	*Panicum acuminatum*	2.74	Wisconsin	widespread	N/A	medium, dry	N/A	Yes*****
little bluestem	*Schizachyrium scoparium*	3.74	Minnesota	widespread	N/A	dry	N/A	Yes
early goldenrod	*Solidago juncea*	12.65	Illinois	widespread	July-Sept	medium	Yes*	N/A
gray goldenrod	*Solidago nemoralis*	13.08	Iowa	widespread	Aug-Oct	medium	Yes*	N/A
awl American-aster	*Symphyotrichum pilosum*	8.72	Minnesota	widespread	Sept-Oct	dry, medium, moist	Yes**	N/A
golden Alexanders	*Zizia aurea*	1.50	Minnesota	widespread	May-July	dry, medium	Yes	N/A
		100						

NOTES:

*The most recurrent host plant genera associations among pollen specialist bee species include Solidago L. (37 spp.). Specialist bees include: Andrena (Callandrena s.l.) aliciae, Andrena (Callandrena s.l.) asteris, Andrena (Cnemidandrena) canadensis, Perdita (Perdita) octomaculata, Pseudopanurgus aestivalis. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html

**The most recurrent host plant genera associations among pollen specialist bee species include Symphyotrichum Nees (32 spp.). Specialist bees include: Andrena (Cnemidandrena) hirticincta, Pseudopanurgus aestivalis, Melissodes (Eumelissodes) dentiventris, Colletes americanus, Dianthidium (Dianthidium) simile. References: https://jarrodfowler.com/specialist_bees.html, https://jarrodfowler.com/host_plants.html

***Little Yellow (Eurema lisa). In both Atlas (1986-90) and MBC (2000-2007) records, Little Yellow ranks as Rare or Very Rare. References: https://www.butterfliesofmassachusetts.net/little-yellow.htm, https://www.butterfliesofmassachusetts.net/methods.htm#Table%205.%20Relative%20Abundance%20MBC/Atlas%20Comparisons, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

****Indian Skipper (Hesperia sassacus) and Leonard's Skipper (Hesperia leonardus). https://www.butterfliesofmassachusetts.net/Leonards.htm, R. Cech and G. Tudor, Butterflies of the East Coast. An Observer's Guide. Princeton University Press, Princeton and Oxford, 2005.

*****Indian Skipper (Hesperia sassacus). Little bluestem (Schizachyrium scoparius), Panicum spp, and Festuca spp. (rubra and obtusa). are the most definite and frequently-reported host grasses, with other species likely (Scott 1986; Opler and Krizek 1984). https://www.butterfliesofmassachusetts.net/indian.htm

Attachment B1
Plantings Table

PLANTINGS NAME: Vegetation Screen
Location to be used: East and south of array

Common Name	Scientific Name	Planting Density	Total # of Plants	Geographic Origin	MA Status	Approx. Bloom Period	Soil Requirements	Specialist Bee Host?	Rare Lepidoptera Host?
Green giant arborvitae	*Thuja standishii x plicata 'Green Giant'*	Staggered rows, 6-8' on center diagonal	141	Massachusetts	cultivar/non-native	N/A	dry, medium	N/A	N/A
Eastern red cedar	*Juniperus virginiana*	Staggered rows, 6-8' on center diagonal	47	Massachusetts	widespread	N/A	dry, medium	N/A	Yes***
American holly	*Ilex opaca*	Staggered rows, 6-8' on center diagonal	47	Massachusetts	fairly widespread	May	medium, moist	Yes*	N/A
Mountain laurel	*Kalmia latifolia*	Staggered rows, 6-8' on center diagonal	46	Massachusetts	widespread	May	medium	Yes**	N/A

NOTES:
*Specialist bee host plant (Colletes banksi; Perdita (Alloperdita) floridensis; Colletes ciliatus) (https://jarrodfowler.com/specialist_bees.html; https://jarrodfowler.com/host_plants.html)
**Specialist bee host plant (Andrena (Conandrena) bradleyi) (https://jarrodfowler.com/specialist_bees.html; https://jarrodfowler.com/host_plants.html)
***Lepidoptera of Conservation Concern host plant (Juniper Hairstreak) https://www.butterfliesofmassachusetts.net/juniper-hairstreak.htm

SOLAR DECOMISSIONING EVALUATION & COST ESTIMATE

DESIGN ENGINEERS, INC.

SOLAR DECOMMISSIONING EVALUATION & COST ESTIMATE

Middleboro Road Solar Project
Freetown, Massachusetts
ADE Project 3220.01

March 12, 2021

This Decommissioning Plan Evaluation has been prepared for the proposed Middleboro Road Solar Project located in Freetown, Massachusetts on behalf of CVE North America, Inc. (the 'Client'). This evaluation has been prepared estimate the costs to remove certain physical components of the proposed project and restore the Site to a stable condition. The assessment also accounts for salvage values associated with materials and a 2% inflation rate using an assumed 20-year lifespan. Please note this evaluation has been completed based upon the plan entitled "Site Development Plans for Middleboro Road Solar Project" drafted by Atlantic Design Engineers Inc. (Atlantic) and dated March 12, 2021.

Upon abandonment or discontinuation of use, the owner shall be responsible for physical removal the Solar Facility following the date of abandonment or discontinuation of use. Based on design criteria at the Site, the definition of "physical removal" shall include, but not be limited to, the following:

1. Contact with local Electrical Distribution Company and schedule a date for shutdown and disconnection from the utility grid as well as provide notice to the Town of such.

2. Removal of the solar modules, supporting structures, foundations, electrical equipment, utility poles and electrical connections. All other equipment, equipment shelters and vaults, security barriers and appurtenant structures shall be removed from the Solar Facility site. Inverters, transformers and the switchgear will be removed from their concrete pads and the pads will be removed as well.

3. Proper disposal of all solid or hazardous materials and wastes (if any) from the site in accordance with local and state solid/hazardous waste disposal regulations,

4. Restoration of the location of the Solar Facility site through the removal of all solar components and seeding of disturbed areas, if needed. This assessment assumes the gravel access drive and the detention basins may remain.

Please refer to the Decommissioning Estimate Calculation Sheet attached as **Exhibit A** for an item-by-item breakdown of the costs associated with the decommissioning of the proposed Middleboro Road Solar Array. A Salvage Estimate of materials or equipment of value has been included within the attached calculations. Salvage items, as listed in **Exhibit A**, will be sold back to the manufacturer or to a recycling facility. Materials of value include but are not limited to copper wiring, aluminum, and steel. Racking materials and fencing will be pulled from the ground, folded for transport and potentially sold to a scrap yard.

The facility owner will be responsible for all decommissioning costs and will obtain all permits or approvals required by the Town prior to commencing decommissioning work.

Assuming a 2% yearly inflation rate for the 20-year proposed project lifespan and considering salvage value**, the estimated future cost of decommissioning the project is <u>$63,500.00</u>**.

The project company will provide a decommissioning guarantee as a condition to receive the certificate of occupancy.

Please feel free to reach me at (508) 888-9282 if you have any questions.

Very truly yours,

ATLANTIC DESIGN ENGINEERS, INC.

Richard J. Tabaczynski, P.E.
Vice President

EXHIBIT A

Exhibit A

Middleboro Road Solar Project Decommissioning Estimate Freetown, MA March 12, 2021	
System Information Summary	
Total System Module Count	6744
Total System Inverter Count	38
Racking Orientation	2 Up Vertical
Linear Feet of Racking	11620.2
Estimated Aluminum per Foot of Racking (lbs)	2
Estimated Steel Per Foot of Racking (lbs)	4.5
Estimated Length of Interconnection to Street (feet)	535
Anticipated Project Lifestpan for Inflation Calcuation (years)	20

Decommissioning Summary		
Estimated Business Days to Demolish (8 Man Crew - Rate of 300 modules, 2 Inverters & 500 Linear Feet of Racking/Day)		29
Estimated Total Number of 40 Yard Dumpsters (400 Modules/2INV/Miscellaneous Debris Per Container)		17
Dumpster Disposal Cost ($600 per Container)	$	10,200.00
Cost for Demolition Crew ($125/Day/Member)	$	29,000.00
Heavy Equipment ($750/Day)	$	21,750.00
Estimated Mobilization & Site Repair (2.5% of Costs)	$	1,523.75
Total Current Day Decommissioning Estimate	**$**	**62,473.75**
Decommissioning Costs Using Lifespean with 2% Inflation	**$**	**92,832.71**

Salvage Value Summary			
Estimated Copper Salvage (lbs)		10,855.15	
Estimated Aluminum Salvage (lbs)		23,240.40	
Estimated Steel Salvage (lbs)		52,290.90	
Current Day Salvage Pricing for Copper ($/lb)	$	0.93	Mid City Scap (3/21)
Current Salvage Pricing for Aluminum ($/lb)	$	0.28	Mid City Scrap (3/21)
Current Salvage Pricing for Steel ($/lb)	$	0.06	Mid City Scarp (3/21)
Estimated Copper Salvage Value	$	10,095.29	
Estimated Aluminum Salvage Value	$	6,507.31	
Estimated Steel Salvage Value	$	3,137.45	
Estimated Total Salvage Value	$	19,740.06	
Estimated Current Day Decommissioning Cost Considering Salvage	**$**	**42,733.69**	
Estimated Future Decommissioning Cost With 2% Inflation and Considering Salvage	**$**	**63,500.02**	

PROOF OF LIABILITY INSURANCE

CVENORT-01 JHOGAN

ACORD

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 11/20/2020

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Roblin Insurance, a division of EPIC
144 Gould Street Suite 100
Needham, MA 02494

CONTACT NAME:
PHONE (A/C, No, Ext): (781) 455-0700
FAX (A/C, No): (781) 449-8976
E-MAIL ADDRESS: certificates@roblininsurance.com

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : AXIS Specialty Europe SE- London Branch	
INSURER B : Lloyd's of London	15792
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
CVE North America, Inc.
109W 27th St., 8th Floor
New York, NY 10011

COVERAGES **CERTIFICATE NUMBER:** **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY						EACH OCCURRENCE	$ 1,000,000
	CLAIMS-MADE X OCCUR			3386420220ES	11/1/2020	11/1/2021	DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 1,000,000
	X Hired/Non Owned Auto						MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 1,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 2,000,000
	POLICY X PRO-JECT LOC						PRODUCTS - COMP/OP AGG	$ 2,000,000
	OTHER:						HNO Auto	$ 1,000,000
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
	ANY AUTO						BODILY INJURY (Per person)	$
	OWNED AUTOS ONLY / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	HIRED AUTOS ONLY / NON-OWNED AUTOS ONLY						PROPERTY DAMAGE (Per accident)	$
								$
A	X UMBRELLA LIAB X OCCUR						EACH OCCURRENCE	$ 10,000,000
	EXCESS LIAB CLAIMS-MADE			3386420320ES	11/1/2020	11/1/2021	AGGREGATE	$ 10,000,000
	DED RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N						PER STATUTE / OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH)	N / A					E.L. EACH ACCIDENT	$
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$
B	Pollution Liability			ENP000458601	6/1/2020	6/1/2021	Ea. Poll Condition	1,000,000
B	Pollution Liability			ENP000458601	6/1/2020	6/1/2021	aggregate	2,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
Issued as Evidence of Insurance

CERTIFICATE HOLDER

Issued as Evidence of Insurance

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
Peter Roblin

SOLAR FACILITY OPERATION & MAINTENANCE PLAN

Operations and Maintenance Plan

Clermont Way, Freetown, MA

CVE is committed to minimizing impact on the land containing the site of the PV array. CVE and its contractors are highly experienced in minimizing the footprint of our solar sites and are enthused to work with local authorities to develop a comprehensive plan to stabilize, inspect, and maintain the land at our construction sites as thoroughly as possible after project completion through the methods described in this O&M Plan.

Environmental Maintenance

- Periodic inspections of the perimeter fence, solar array, and connecting infrastructure will be made by the maintenance contractor.
- Repairs to the security fence, including fence within the 100-foot buffer zone to wetlands, shall be made as needed.
- Erosion in access roads shall be repaired and stabilized.
- Fence panels shall be raised approximately 6-inches off the ground to permit movement of ground dwelling animals.
- Access roads shall be maintained.
- Culverts shall be maintained as necessary, including cleaning or replacement.
- Tall vegetation surrounding the solar array and within the new utility right-of-way will be maintained to prevent shading of the array and the obstruction of the overhead electrical wires, respectively.
- Mowing will occur approximately once per year under and around the solar array.
- Similarly, invasives and other unwanted plants in the trim zone (shade management area) will be tagged by a botanist using either orange or green flagging and thus so removed. Native plants that reach a height of more than 12-15' may also be flagged for removal from the trim zone at any point if they threaten to shade any portion of the solar array. All native vegetation under 10' height found anywhere in the trim zone will be left undisturbed, unless necessary for safety, equipment access or maintenance of other areas.

Below is a list of the Environmental Maintenance practices that will take place detailing their frequencies.

Scope of the Environmental Maintenance Services	Frequency
General	
Perimeter fence inspection	Annual
Repairs to the security fence, including fence within the 100-foot buffer zone to wetlands	Annual
Access road erosion inspections	Annual
Access road repair (Hand Tools only)	Per occurrence
Access road repair (Heavy Machinery)	Per occurrence
Culvert Inspection	Annual
Culvert cleaning	Per occurrence
Culvert repair	Per occurrence
Tall vegetation inspection	Annual
Tall vegetation maintenance	Per occurrence

Mowing	Biannual
Trim Management Area inspection	Annual

Corrective Maintenance

CVE North America subcontracts Corrective Maintenance measures to NABCEP certified Licensed Electricians like PVPros, Engie, SMA, and local firms. To maintain our 99% availability company goal, we work with our maintenance providers to adhere to time-based response guarantees. Below is the scope of our typical corrective maintenance duties.

Corrective Maintenance Services	Estimated # of occurrences per 20 years
Modules and Module Wiring	
Replacement	20
Ground fault troubleshooting	5
Inverters	
Replacement	10
Fuse replacement	20
Medium Voltage gear	
Replacement	1
Road maintenance	
Regrade/compact	0 - 1

Preventive Maintenance

In order to guarantee the durability and quality of the plant over time, preventive maintenance visits are organized multiple times per year on each site. This visit, carried out by specialized technicians, includes the interventions listed below.

Scope of the Preventive Maintenance Services	Frequency
General	
General Visual inspection	Biannual
General cleaning of the PV System from waste	Biannual
Checking of the general condition of the building	Annual
Checking water seepage	Annual
Visual inspection and/or maintenance of the road with hand tools only	Annual

Maintenance of the road with heavy machinery	Per occurrence
Visual inspection of earthing, Riso measurement and continuity check of grounding	Annual
Inverters	
Visual inspection, internal and external cleaning	Annual
Checking the correct ventilation of the equipment and filter cleaning	Annual
Checking cables for tight connections	Annual
Checking alarms from local display and coherence with the monitoring system	Annual
Checking for overheating point with thermal imaging camera (where permitted by manufacturer)	Annual
Control of protection devices of the inverters	Annual
String Boxes	
Visual inspection inside and outside	Annual
Measurement of load current and unload voltage of all strings (check coherence with monitoring)	Annual
Continuity of string fuses	Annual
Grounding condition checking	Annual
Re-tighten the panel protection device screws, ring terminal	Annual
Checking surge arrestors conditions	Annual
Checking the control panel light and indicators	Annual
Checking for overheating point with thermal imaging camera	Annual
Low Voltage Cabinet and Distribution Panels	
External visual inspection: integrity, hardware, network connections to earth	Annual
Internal visual inspection and cleaning	Annual
Checking internal components	Annual
Checking cables for tight connections	Annual
Checking for possible excessive overheating	Annual
Checking for overheating point with thermal imaging camera	Annual
Medium Voltage Switchgear And Energy Measurement	
General cleaning of the switchgear (internal and external)	Annual
Checking correct electrical and mechanical operation of disconnects and switches	Annual
Checking cables for tight connections	Annual
Checking of the anticondensation heaters	Annual
Checking condition of insulators and bus bars	Annual
Greasing lever system	Annual
Checking for possible excessive overheating	Annual

Checking for overheating point with thermal imaging camera	Annual
Checking and write down the index of the Energy meter	Annual
Transformer	
Checking operation load level of measurement equipment	Annual
Checking oil temperature indicator	Annual,
Testing of gas, pressure, temperature relay on oil transformer	Annual
Checking of the operation of the protection with the relay	Annual
Oil analysis	Every 2 years
Checking moisture content of power transformer oil	Annual
Checking status of current equipment for motor control	Annual
Checking Status of power transformer protection	Annual
Checking sealing of all joints of the power transformer	Annual
Checking the heating elements functioning of the power transformer.	Annual
General cleaning	Annual
Checking for overheating point with thermal imaging camera	Annual
Racking	
Inspection of the elements that make up the foundation, checking for damage or cracks on it	Annual
Visual check of the status of the torque marks	Annual
Checking of anchor fastening hardware to the structure	Annual
Checking for corrosion in the structure	Annual
Checking of proper grounding of the structure	Annual
Solar Modules	
100% visual inspection of solar modules. Checking the status of the modules (glass, frame), wiring and junction boxes.	Annual
Visual check of stability, rigidity and fixing of the modules	Annual
Visual check of connectors and cables	Annual
Thermography on 100% of solar modules	Every 2 years
DC Cable	
Visual check and tightening of connections, strings, boxes, fuse box switchgear.	Annual
Visual inspection of insulation damage, scratches, abrasions, climb cables etc.	Annual
Visual inspection of wire management, fixing where necessary	Annual
Security System (if applicable)	
Maintenance of the control room	Annual
Testing of the normal operation of the cameras and detection system	Annual

Checking of alarm system by SMS and e-mail.	Annual
Checking the image recording system.	Annual
Checking focus, visual field and cleaning the lens of camera.	Annual
Checking the configuration of the main operating parameters.	Annual
Fence	
Status checking of perimeter fence and status checking of access gates.	Annual
Monitoring / Communication	
Visual check of the datalogger and all connection cable	Annual
Checking of the events history logging	Annual
Connection to the datalogger and check of the parameters and communication with materials	Annual
Changing battery of the UPS (this is only on the DAS)	Every 2 years
Testing of communication with monitoring remote center	Annual
Replacement of batteries of the UPS	Every 2 years
Weather Station	
General inspection of the elements	Biannual
Cleaning of the pyranometers	2 times a year
Re-calibration of pyranometers and temperature sensors	Every 2 years
Review the bolt fastenings and check the condition of the supports for the sensors	Annual
Modules Cleaning	
Cleaning of 100% of the modules	Per Occurrence

Operations and Maintenance Budget

To account for all corrective, preventive and environmental maintenance required on site, CVE estimates an annual Operations and Maintenance budget of around $10-15/kW. CVE commits to share annual O&M reports with the town of Freetown.

WETLANDS DELINEATION REPORT

SABATIA, Inc.
ROBERT M. GRAY, P.W.S., C.S.E., R.S.
21 Observatory Lane, Pocasset, MA 02559
Tel (508) 563-5349 sabatia@comcast.net

January 8, 2021

Mr. Asa Smith
Environmental Scientist
Atlantic Design Engineers, Inc.
39 Pleasant Street
Sagamore, MA 02561

RE: Site Assessment/Wetland Delineation @ 32 Middleboro Road, East Freetown (Assessor ID: Map 245, Lots 30 & Lots 30-01-30-07

Dear Mr. Smith:

As requested by Atlantic Design Engineers, Inc., Sabatia, Inc. conducted a site assessment and performed a wetland delineation on December 7, 2020 on a parcel of land off Middleboro Road (Assessor ID: Map 245, Lots 30 & Lots 30-01-30-07 @ 32 Middleboro Road. The purpose of the site assessment was to determine the applicability of MGL Chapter 131, Section 40 (The Massachusetts Wetlands Protection Act) and its regulations @ 310 CRM 10.00 et seq. The wetland boundary had been previously flagged by Sabatia, Inc. and before Sabatia, Inc. "by others". This work was initially performed for an 8-Lot subdivision off the proposed "Clermont Way".

<u>Plan of Record</u>:

The Plan of Record (POR) is titled "*Wetland Location Plan, for 32 Middleboro Road, Freetown, Massachusetts 02717",* dated December 18, 2020 and with a scale of 1" = 50', prepared by Atlantic Design Engineers, Inc. and prepared for CVE North America, Inc. 109 W 27th Street, 8th Floor, New York, NY 10001.

<u>Findings</u>:

The site assessments revealed that the subject lots are composed of both undeveloped upland and a bordering vegetated wetland (BVW-310 CMR 10.55) which borders on an intermittent stream (IS-310 CMR 10.56) and its associated inland bank (IB-310 CMR 10.54). The wetland resource areas (WRAs) and an associated 100' buffer zone would be subject to the jurisdiction of MGL c. 131, s. 40 and any local Wetlands Protection Bylaw (if applicable).

On December 7, 2020, Sabatia, Inc. set wetland flag stations WF-1-1 to WF-1-19, WF-2-1 to WF-2-14 and WF-3-1 to WF-3-14. Sabatia, Inc. utilized the required "three parameters" methodology dictated in 310 CMR 10.55 (2a) using "vegetation, soils & hydrology".

This BVW borders an intermittent stream (IS-310 CMR 10.56) and its associated inland bank (IB-310 CMR 10.54). The IS had steady flow on the date of the site assessment/wetland delineation-12-7-2020 (following about a recent 3" rainfall). NOTE: The area delineated does not show either intermittent or perennial stream courses on the USGS Topo Sheet (Assawompset Pond/Quad1978/attached). There is therefore no Riverfront (310 CMR 10.58) associated with these lots. I have also attached the DEP Wetland Change Map and a Soil Map.

Upland Areas:

The upland areas were not assessed by Sabatia, Inc. in the field as there were no areas of potential wetlands indicated on the DEP Wetland Change Map, Soil or the USGS Topo Sheet. A previous survey of the land depicts two-foot contours across the upland area with no depressions indicated. The general slope is downward from elevation 112 to elevation 82 at the northern PL (where a detention basin was formerly proposed). Furthermore, no potential wetlands were identified by the prior engineer or surveyor for the approved 2017 Subdivision project, as evidence by the proposed development plan of the subdivision (attached).

The attached Soil Map indicates the upland areas are underlain by nonhydric soils (307B & 312B) with some possible "hydric" inclusions. I have included a Google Earth picture from March 31, 2005 which depicts a tree canopy in green. This is indicative of evergreens and is most likely an area forested with white pine (upland tree species).

I would recommend that any suspicious areas within the uplands noted by the Land Survey team be further evaluated by Sabatia, Inc.

Finally, I have also attached the MNHESP map (rare species) which indicates no portion of the parcel is within or near the closest mapped Priority Habitat (PH-453).

I would be pleased to walk the parcel with you and/or members of the Freetown Conservation Commission and/or the Conservation Agent. Please feel free to contact me at 1-508-563-5349 or by email at sabatia@comcast.net.

Sincerely yours,
Robert M. Gray, SPWS, RS, CSE
Senior Professional Wetland Scientist, #160
Registered Sanitarian (RT), #669
DEP Certified Soil Evaluator (RT), #936

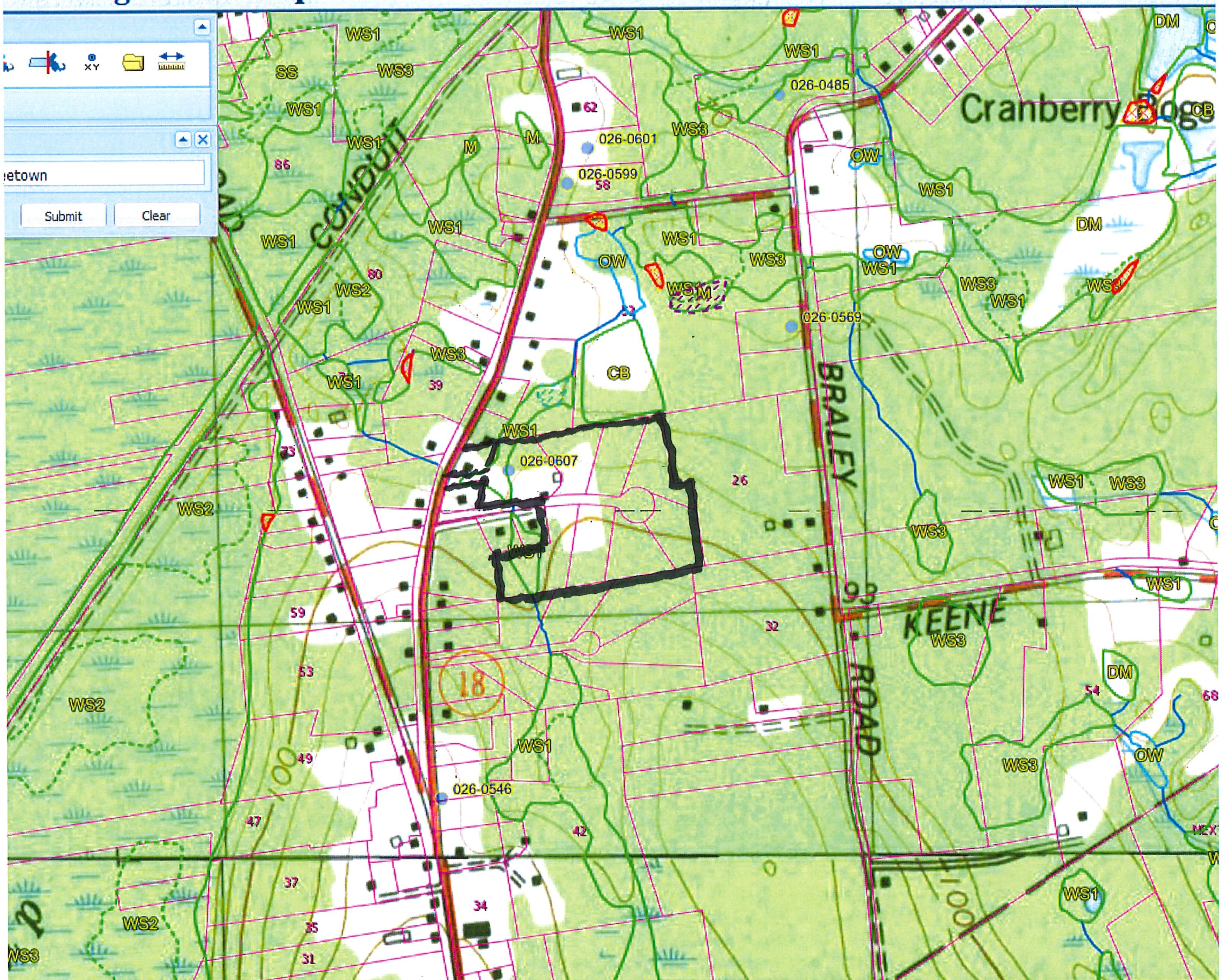
Society of Wetland Scientists
ROBERT M. GRAY
SWS
000160
Professional Wetland Scientist

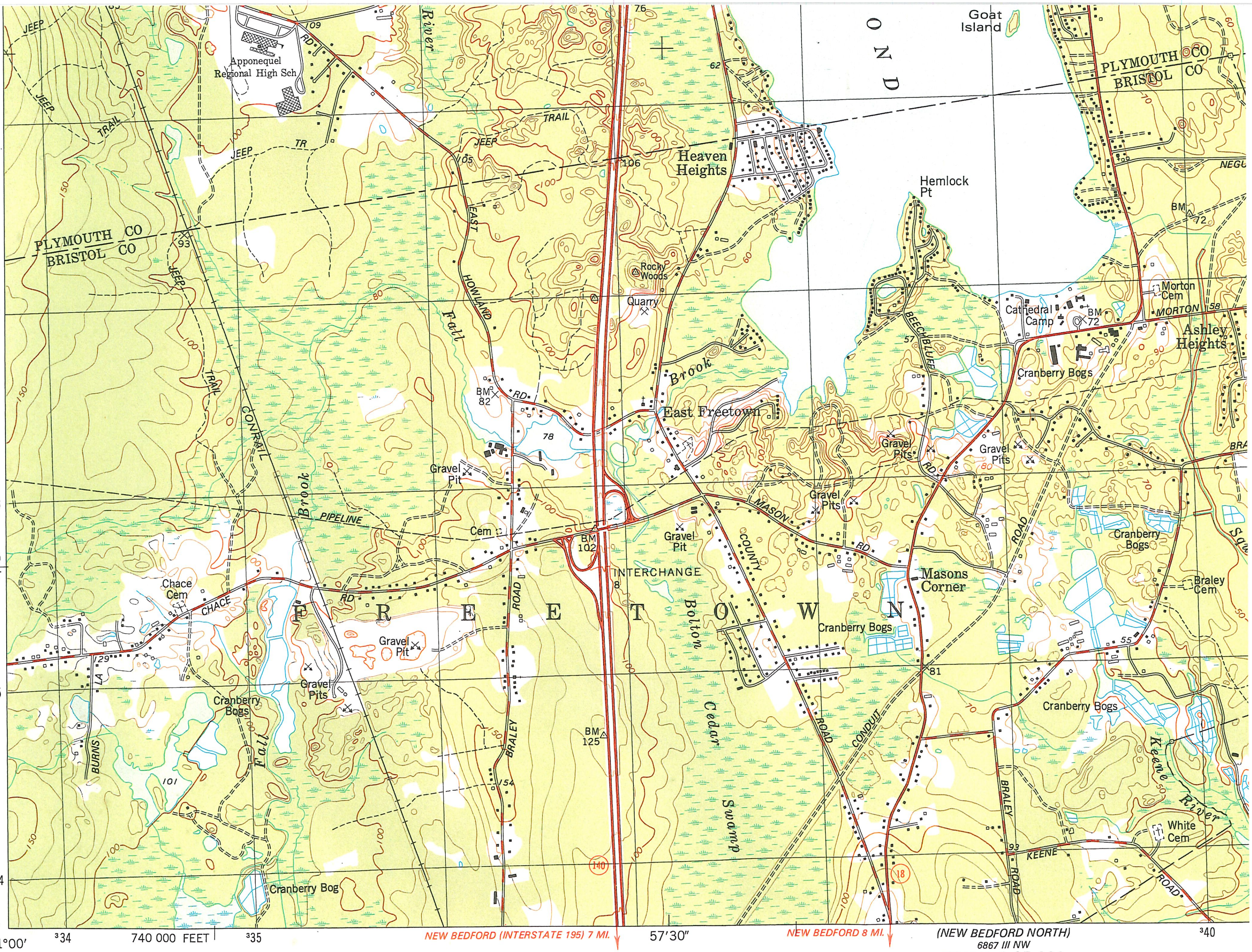
naps.massgis.state.ma.us/images/dep/omv/wetviewer.htm

Search

Vetland ...

d Change Areas Map





(NEW BEDFORD NORTH)
6867 III NW

SCALE 1:25 000

Mapped, edited, and published by the Geological Survey

Control by USGS, NOS/NOAA, and Massachusetts Geodetic Survey etland Change Area ✕ +

naps.massgis.state.ma.us/images/dep/omv/wetviewer.htm

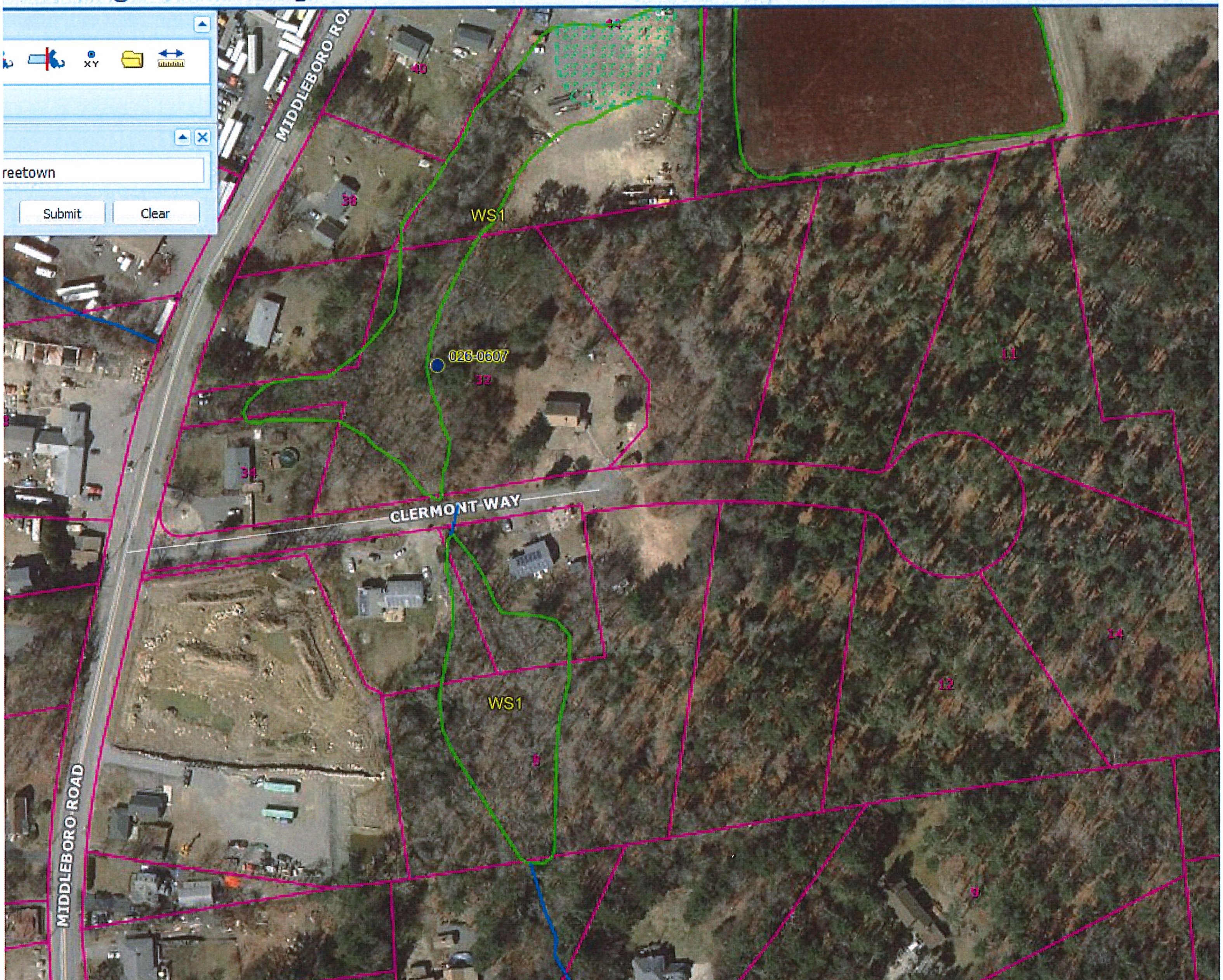
Search

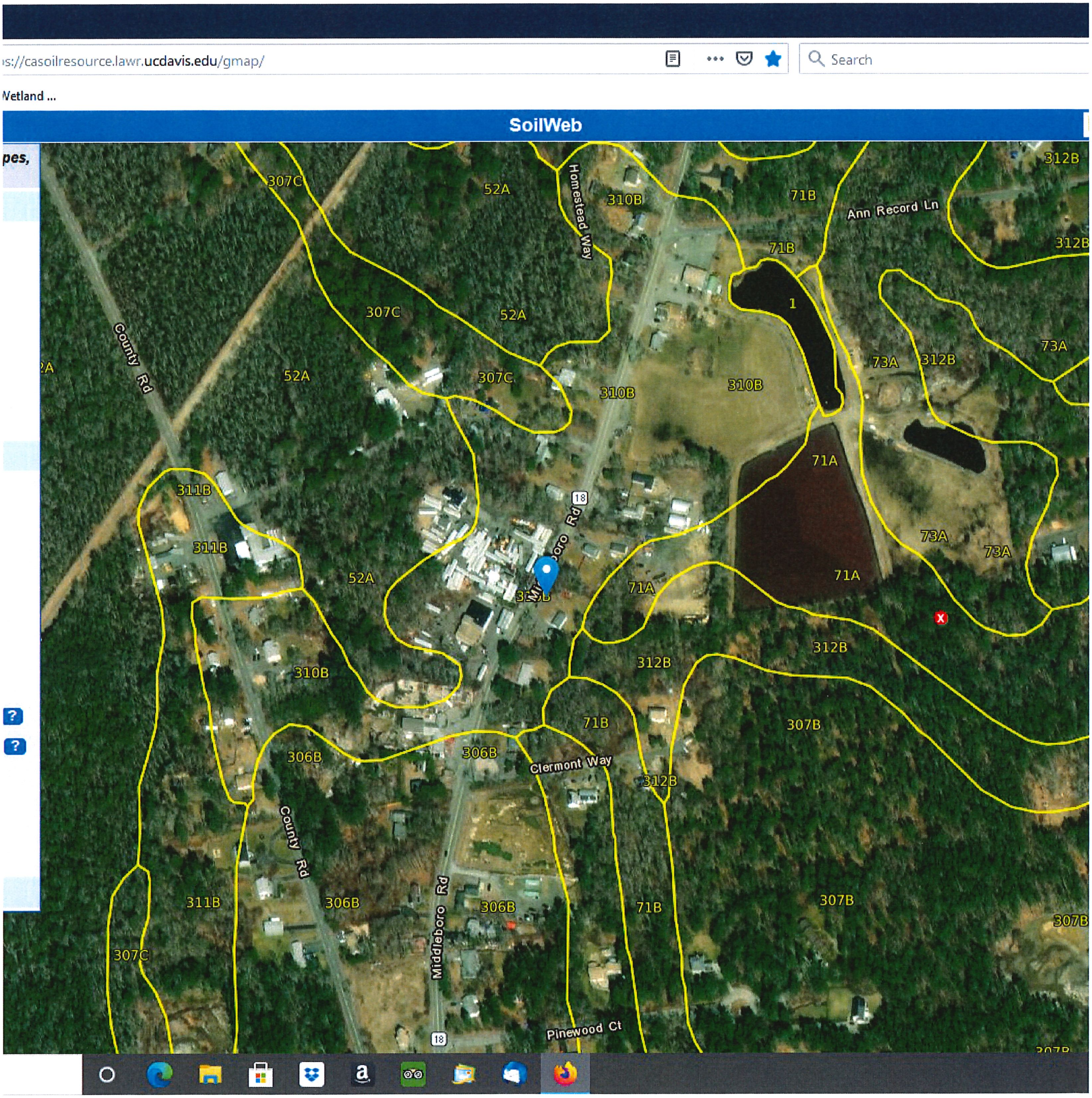
Vetland ...

d Change Areas Map

reetown

Submit Clear





:s://casoilresource.lawr.ucdavis.edu/gmap/
Search
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Homestead Way
310B
71B
Ann Record Ln
312B
1
307C
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73A
312B
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County Rd
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County Rd
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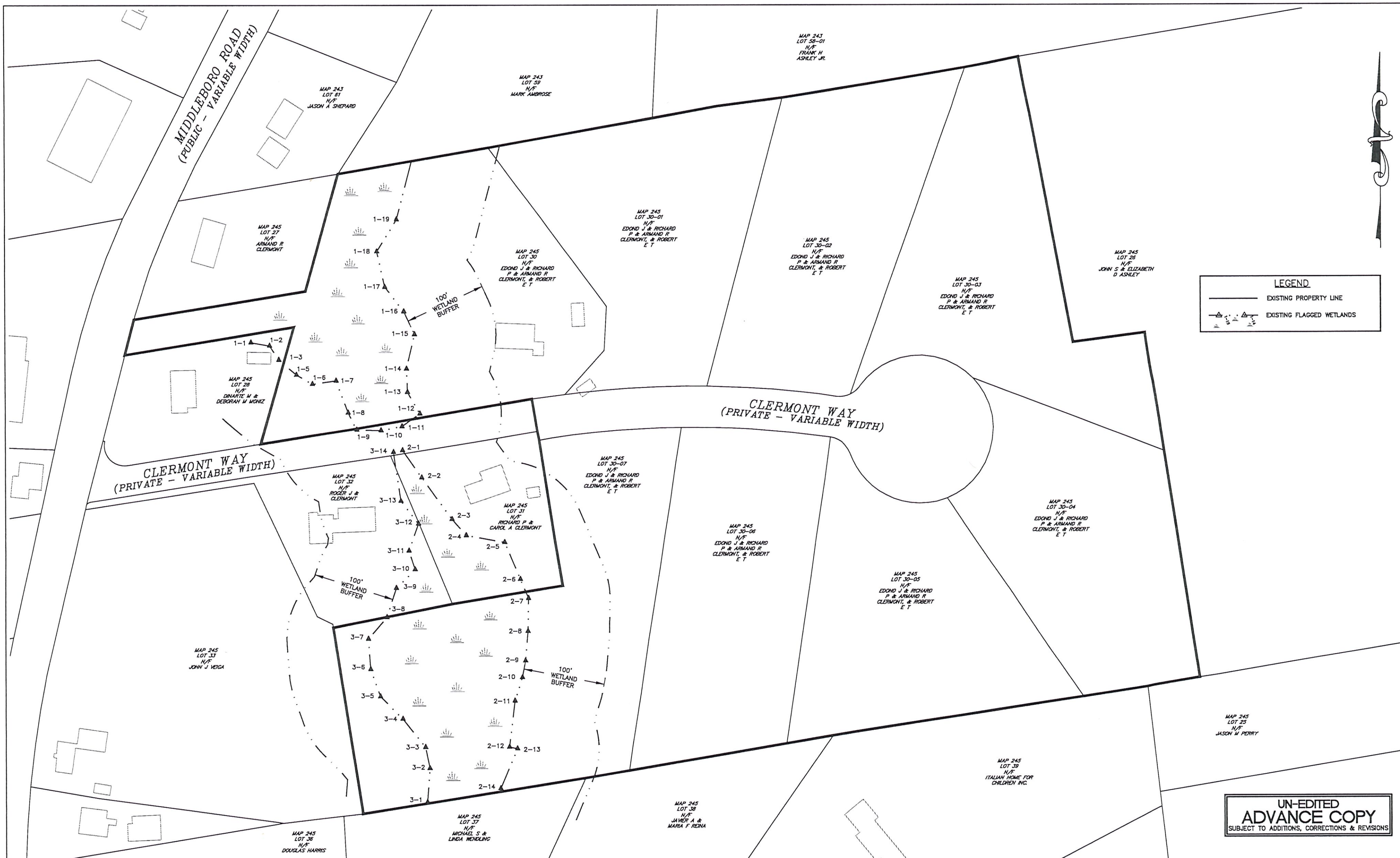
307C
Middleboro Rd
18
Pinewood Ct



FILE: 3220.00-WLP

Atlantic® DESIGN ENGINEERS, INC.
P.O. Box 1051, Sandwich, MA 02563 (508) 888 - 9282

Designed by :
Drawn by :
Checked by :
Survey chk. by :
Approved by :

SCALE
SCALE 1" = 50'
0 25 50 100

DATE

NO.	BY	DATE	REVISION

PREPARED FOR
CVE NORTH AMERICA, INC.
109 W 27TH STREET, 8TH FLOOR
NEW YORK, NY 10001

WETLAND LOCATION PLAN
FOR
32 MIDDLEBORO ROAD
FREETOWN, MASSACHUSETTS 02717
DECEMBER 18, 2020

Sheet 1 of 1
JOB NUMBER
3220.00

NOTES:

1.) OWNER: EDMOND J., RICHARD P., ARMAND R., & ROBERT E. CLERMONT
PO BOX 711
E. FREETOWN, MA 02717

2.) LOCUS IS SHOWN AS LOT 29 & 30 ON FREETOWN ASSESSOR'S MAP 245.

3.) LOCUS DEED REFERENCE:
1.) DEED BOOK 3508, PAGE 28

4.) PLAN REFERENCES:
1.) PLAN BOOK 39, PAGE 26
2.) PLAN BOOK 57, PAGE 79
3.) PLAN BOOK 102, PAGE 31
4.) PLAN BOOK 147, PAGE 27
5.) PLAN BOOK 94, PAGE 22

5.) PROPERTY IS LOCATED WITHIN FEMA FLOOD ZONE X AS SHOWN ON PANEL #25005CO289G, DATED JULY 16, 2015.

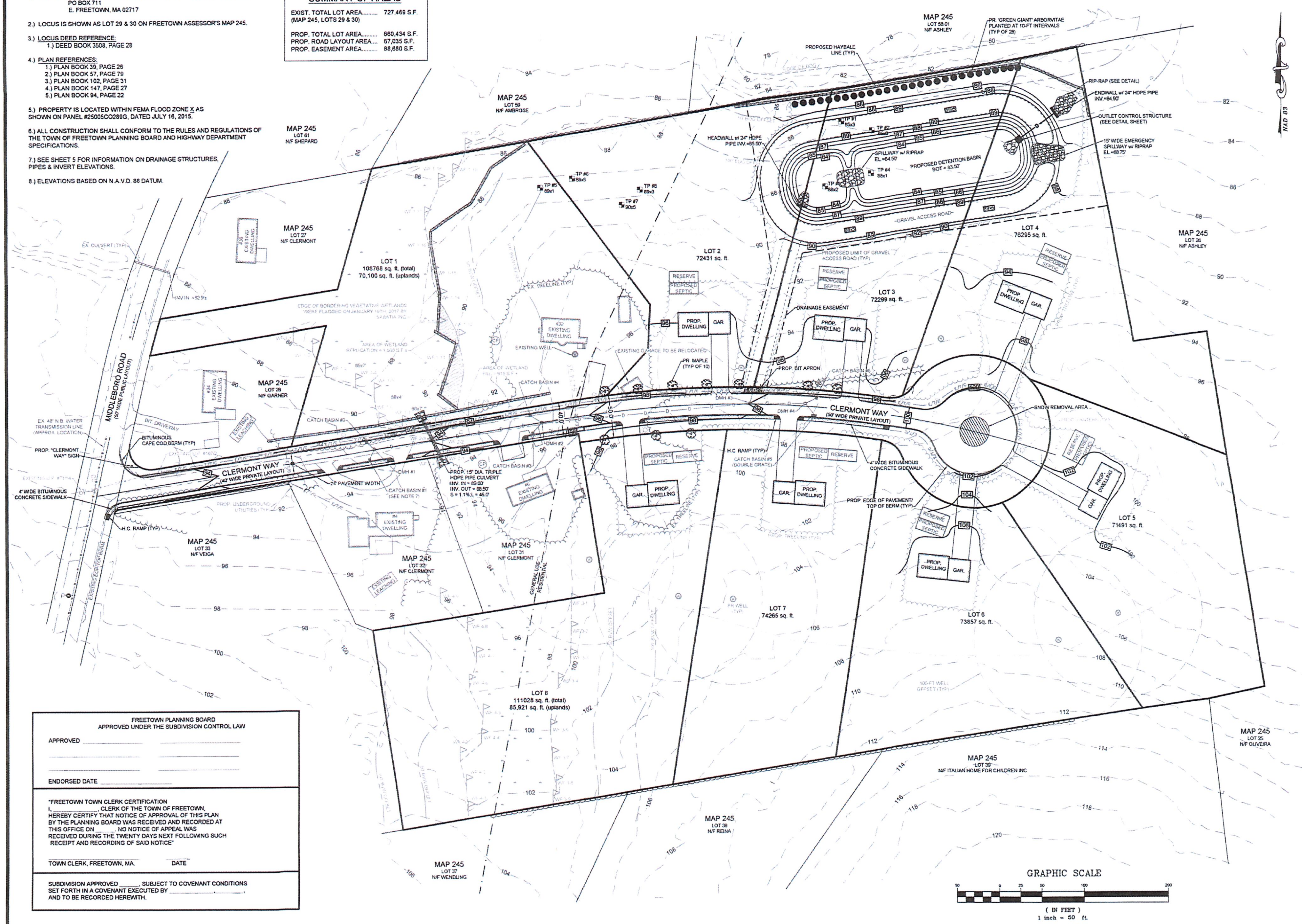
6.) ALL CONSTRUCTION SHALL CONFORM TO THE RULES AND REGULATIONS OF THE TOWN OF FREETOWN PLANNING BOARD AND HIGHWAY DEPARTMENT SPECIFICATIONS.

7.) SEE SHEET 5 FOR INFORMATION ON DRAINAGE STRUCTURES, PIPES & INVERT ELEVATIONS.

8.) ELEVATIONS BASED ON N.A.V.D. 88 DATUM.

SUMMARY OF AREAS

EXIST. TOTAL LOT AREA (MAP 245, LOTS 29 & 30)	727,469 S.F.
PROP. TOTAL LOT AREA	660,434 S.F.
PROP. ROAD LAYOUT AREA	67,035 S.F.
PROP. EASEMENT AREA	88,680 S.F.



FREETOWN PLANNING BOARD
APPROVED UNDER THE SUBDIVISION CONTROL LAW

APPROVED ________________ ________________

________________ ________________

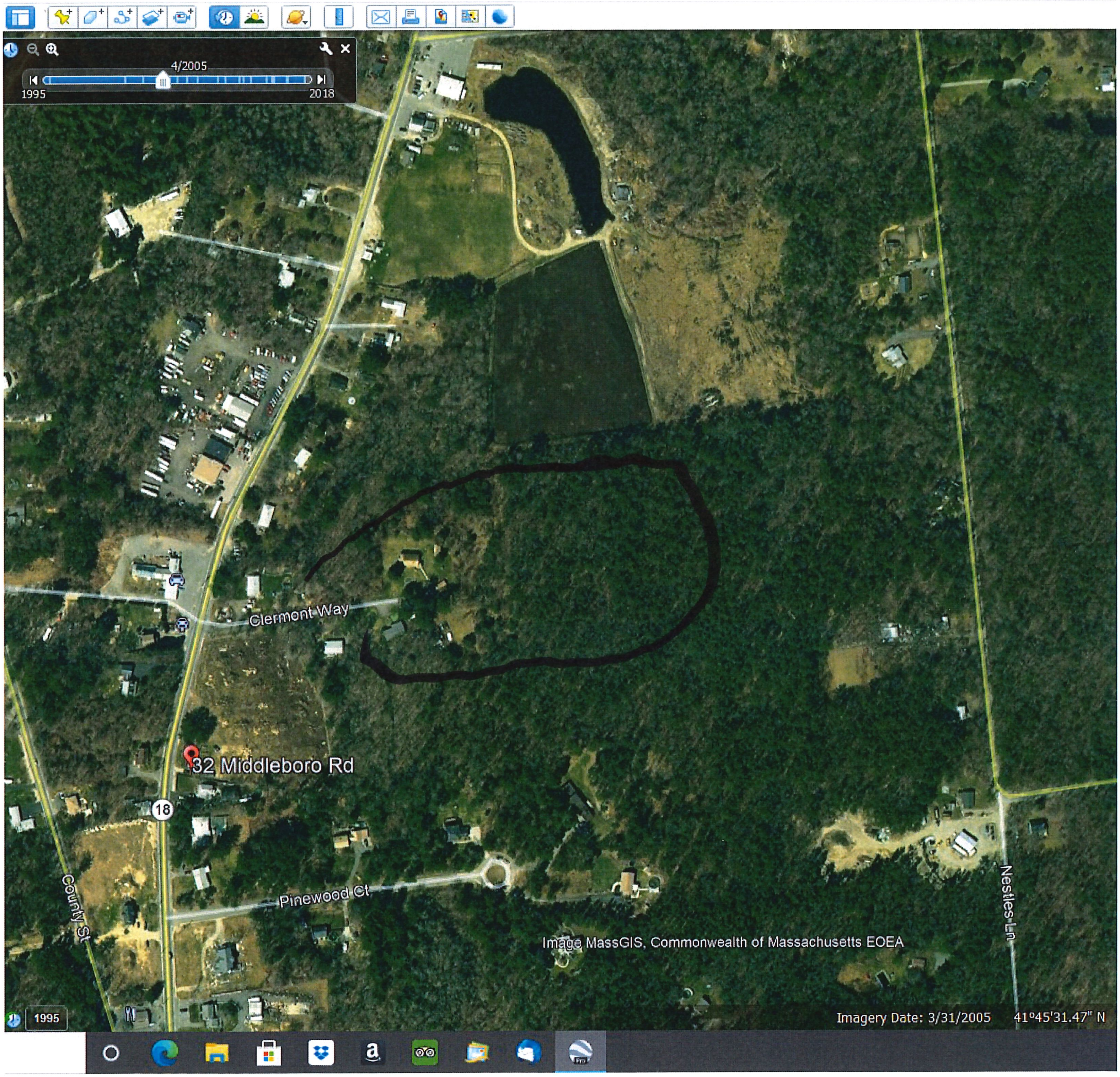
________________ ________________

ENDORSED DATE ________________

"FREETOWN TOWN CLERK CERTIFICATION
I, ________________, CLERK OF THE TOWN OF FREETOWN, HEREBY CERTIFY THAT NOTICE OF APPROVAL OF THIS PLAN BY THE PLANNING BOARD WAS RECEIVED AND RECORDED AT THIS OFFICE ON ______. NO NOTICE OF APPEAL WAS RECEIVED DURING THE TWENTY DAYS NEXT FOLLOWING SUCH RECEIPT AND RECORDING OF SAID NOTICE"

TOWN CLERK, FREETOWN, MA. ________ DATE

SUBDIVISION APPROVED ______, SUBJECT TO COVENANT CONDITIONS SET FORTH IN A COVENANT EXECUTED BY ________, ________, AND TO BE RECORDED HEREWITH.

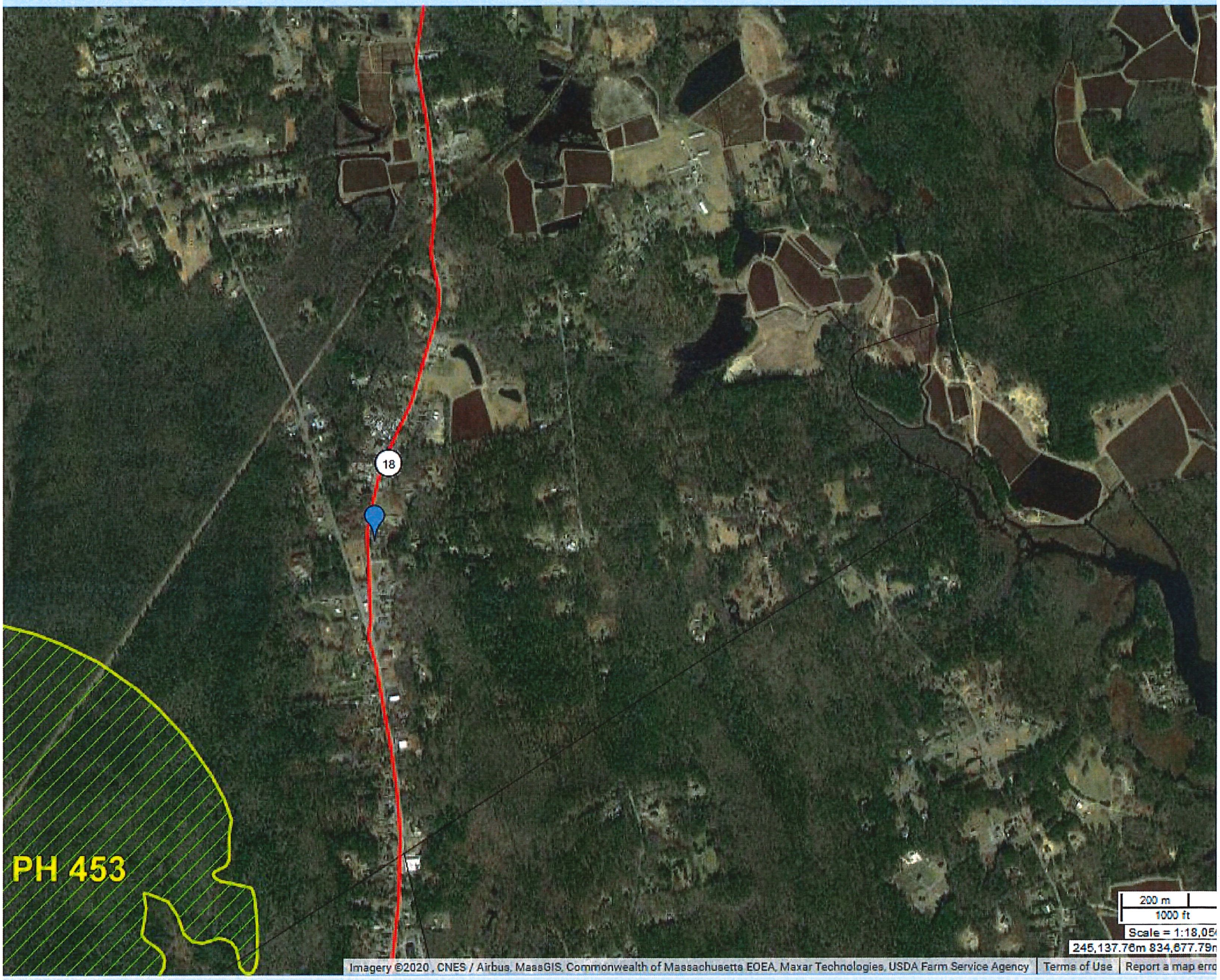


Google Earth 3-31-2005

er.php?lyrs=NHESP Priority Habitats of Rare Species~massgis:GISDATA.PRIHAB_POLY~GISDATA.PRIHAB_POLY::Default|NHESP Estimated Habitats of Rare Wildlife~massgis:(

apping Tool Please take our user survey

32 Middleboro Road, East Fre Zoom to a town



Basemaps

HAZARDOUS MATERIAL ASSURANCE LETTER

Atlantic
DESIGN ENGINEERS, INC.

March 12, 2021

C. Nils McKay, Planning Technician
Freetown Planning Board
Freetown Town Hall
3 North Main Street
Assonet, MA 02702

Re: ***Hazardous Material Assurance Letter***
Middleboro Road Solar Project – Site Plan Review Application
32 Middleboro Road, Freetown, MA

Dear Members of the Planning Board:

This letter presents an assurance that the solar panels, transformers and battery storage systems proposed for the Middleboro Road Solar Project do not contain hazardous materials.

Per the *Question and Answer – Ground Mounted Solar Photovoltaic Systems* guide from the Massachusetts Department of Energy Resources, Massachusetts Department of Environmental Protection and Massachusetts Clean Energy Center dated June 2015, all solar panel materials are: (1) contained in a solid matrix, (2) insoluble and non-volatile at ambient conditions. Therefore, releases to the ground from leaching, to the air from volatilization during use, or from panel breakage, are not a concern. Particulate emissions could only occur if the materials were ground to a fine dust, but there is no realistic scenario for this occurrence. A excerpt of this guide can be found attached as **Appendix A**.

Additionally, there are no hazardous materials to be permanently introduced or stored on the site as part of the solar panel installation. The solar panels are to be mounted on stationary racking systems with no movable parts.

Examples of panel materials from the proposed solar panels (Q-Cell) have been added in **Appendix C**. The electrical transformers contain a non-toxic, biodegradable, vegetable-based coolant known as Envirotemp FR3 fluid which is not classified as a hazardous material according to the EPA, OSHA, per the FR3 Fluid product Material Safety Data Sheets (MSDS) & Environmental FAQs attached as **Appendix B**. Additionally, solar panel MSDS information (Q-Cell) can be found attached as **Appendix C**. MSDS information as well as fire safety and suppression information to be used on site for the battery storage system is located in **Appendix D**. Additional studies regarding Health and Safety Impacts of Solar field by NC State University and goodcompany can be found in **Appendix E.**

The proposed battery systems for the project consist of Sungrow Model CS100 Lithium-Ion Battery Cells that are grouped together into modules placed in outdoor rated enclosures which are fabricated to include thermal management, racks for battery modules, fire suppression, and various safety equipment. Additionally, components used in the proposed battery storage system adhere to all UL, Electrical Permits and National Electrical Code (NEC) standards and the battery system installations are designed and engineered by licensed electrical engineers in accordance with NEC/National Fire Protection Association regulations.

Lithium-Ion battery systems are typically designed for a 10-20-year useful life. Lithium-Ion batteries degrade over time with use and their inherent shelf-life. Upon decommissioning, battery cells that are no longer usable and will be sent to an appropriate receiving facility for either recycling or re-purposing. A guide to the recycling of large-scale battery systems can be found in **Appendix D**. The MSDS information for the proposed Sungrow Model CS100 Lithium-Ion Battery Cells can also be found in **Appendix D.**

If you have any questions, please feel free to contact us at (508) 888-9282.

Very truly yours,

Sincerely,

ATLANTIC DESIGN ENGINEERS, INC.

Richard J. Tabaczynski, P.E.
Vice President

Appendix A

Question and Answer – Ground Mounted Solar Photovoltaic Systems

Massachusetts Department of Energy Resources
Massachusetts Department of Environmental Protection
Massachusetts Clean Energy Center

June 2015

CLEANENERGYRESULTS

Questions & Answers

Ground-Mounted Solar Photovoltaic Systems

Westford Solar Park, photo courtesy of EEA

June 2015

Massachusetts Department of Energy Resources
Massachusetts Department of Environmental Protection
Massachusetts Clean Energy Center

Table of Contents

Background

Encouraging increased use of solar photovoltaic (PV) technology, which converts sunlight directly into electricity, is a key priority for state clean energy efforts. The environmental benefits of solar PV abound. Unlike conventional fossil fuel power generation (such as coal, gas and oil), generating electricity with ground-mounted solar PV involves no moving parts, uses no water, and produces no direct emissions of climate-warming greenhouse gases.

Solar PV environmental and energy benefits, combined with strong incentives available for solar projects, have significantly increased the use of this technology recently. The Commonwealth's vibrant solar industry has a variety of ownership and financing options for Massachusetts residents and businesses looking to install solar PV systems. Purchasing a solar PV system generally involves upfront installation and equipment costs, but there are significant upfront and production-based incentives[1].

As the Massachusetts clean energy sector grows, the Baker Administration is working to ensure that solar PV and other clean energy technologies are sited in a way that is most protective of human health and the environment, and minimizes impacts on scenic, natural, and historic resources.

Purpose of Guide

This guide is intended to help local decision-makers and community members answer common questions about ground-mounted solar PV development. Ground-mounted solar PV has many proven advantages and there has been a steady growth of well received projects in the Commonwealth. However, these systems are still relatively new and unfamiliar additions to our physical landscape.

This guide focuses on questions that have been raised concerning the installation and operation of ground-mounted solar PV projects. It provides summaries and links to existing research and studies that can help understand solar PV technology in general and ground-mounted solar in particular.

Solar PV panels can and are of course also installed on buildings[2], car ports or light poles. This guide focuses on ground-mounted systems since most questions relate to this type of solar installation.

Developed through the partnership of the Massachusetts Department of Energy Resources (DOER), the Massachusetts Department of Environmental Protection (MassDEP), and the Massachusetts Clean Energy Center (MassCEC), this guide draws from existing recent literature in the United States and abroad and is not the result of new original scientific studies. The text was reviewed by the National Renewable Energy Laboratory (NREL).

As more or new information becomes available, the guide will be updated and expanded accordingly.

[1] For a comprehensive overview, start at http://masscec.com/index.cfm/page/Solar-PV/pid/12584

[2] For an overview of the multiple options for siting PV and buildings in the same footprint, see the Solar Ready Buildings Planning Guide, NREL, 2009.

Solar PV Projects Are Sited Locally

The siting authority for solar PV projects resides at the local - not the state - level. One purpose of this guide is to inform and facilitate local efforts to expand clean energy generation in a sustainable way, and provide a consolidated source of existing research and information that addresses common questions faced by communities.

As part of the Green Communities Act of 2008, DOER and the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) developed a model zoning by-law/ordinance called "as-of-right siting" that does not require a special permit. It is designed to help communities considering adoption of zoning for siting of large-scale solar. This model zoning by-law/ordinance provides standards for the placement, design, construction, operation, monitoring, modification and removal of new large-scale ground-mounted solar PV installations. The latest version of the model by-law was published in December 2014[3]. It provides useful information that will not be repeated extensively in this guide.

Consider Impacts of Other Possible Developments at Site

Use of land for the purpose of solar photovoltaic power generation should be compatible with most other types of land usage. However, DOER strongly discourages designating locations that require significant tree cutting because of the important water management, cooling and climate benefits trees provide. DOER encourages designating locations in industrial and commercial districts, or on vacant, disturbed land.

When assessing the impact of new ground-mounted solar arrays, communities and other stakeholders should carefully consider other types of development that might take place in a particular location if there was no solar installation. Stakeholders should bear in mind the higher or lower impacts that those alternatives might have in terms of noise, air pollution or landscape. These alternative impacts fall outside the scope of this guide, but are relevant when looking at individual projects.

[3] http://www.mass.gov/eea/docs/doer/green-communities/grant-program/model-solar-zoning.pdf

Hazardous Materials

The Question: What, if any, health risks do chemicals used to manufacture solar panels and other devices used in solar PV arrays pose if they are released into the environment?

Bottom Line: Because PV panel materials are enclosed, and don't mix with water or vaporize into the air, there is little, if any, risk of chemical releases to the environment during normal use. The most common type of PV panel is made of tempered glass, which is quite strong. They pass hail tests, and are regularly installed in Arctic and Antarctic conditions. Only in the unlikely event of a sufficiently hot fire is there a slight chance that chemicals could be released. This is unlikely because most residential fires are not hot enough to melt PV components and PV systems must conform to state and federal fire safety, electrical and building codes.

Transformers used at PV installations, that are similar to the ones used throughout the electricity distribution system in cities and towns, have the potential to release chemicals if they leak or catch fire. Transformer coolants containing halogens have some potential for toxic releases to the air if combusted. However, modern transformers typically use non-toxic coolants, such as mineral oils. Potential releases from transformers using these coolants at PV installations are not expected to present a risk to human health.

More Information: Ground-mounted PV solar arrays are typically made up of panels of silicon solar cells covered by a thin layer of protective glass, which is attached to an inert solid underlying substance (or "substrate"). While the vast majority of PV panels currently in use are made of silicon, certain types of solar cells may contain cadmium telluride (CdTe), copper indium diselenide (CIS), and gallium arsenide (GaAs).

All solar panel materials, including the chemicals noted above, are contained in a solid matrix, insoluble and non-volatile at ambient conditions, and enclosed. Therefore, releases to the ground from leaching, to the air from volatilization during use, or from panel breakage, are not a concern. Particulate emissions could only occur if the materials were ground to a fine dust, but there is no realistic scenario for this. Panels exposed to extremely high heat could emit vapors and particulates from PV panel components to the air. However, researchers have concluded that the potential for emissions derived from PV components during typical fires is limited given the relatively short-duration of most fires and the high melting point (>1000 degrees Celsius) of PV materials compared to the roof level temperatures typically observed during residential fires (800-900 degrees Celsius). In the rare instance where a solar panel might be subject to higher temperatures, the silicon and other chemicals that comprise the solar panel would likely bind to the glass that covers the PV cells and be retained there.

Release of any toxic materials from solid state inverters is also unlikely provided appropriate electrical and installation requirements are followed. For more information on public safety and fire, see the Public Safety section of this document.

We should also note that usually the rain is sufficient to keep the panels clean, so no extra cleaning in which cleaning products might be used, is necessary.

Resources:

Fthenakis, V.M., Overview of Potential Hazards in *Practical Handbook of Photovoltaics: Fundamentals and Applications, General editors T. Markvart and L. Castaner, to be published by Elsevier in 2003*.

Fthenakis, V.M. Life cycle impact analysis of cadmium in CdTe PV production. Renewable and Sustainable Energy Reviews 8, 303-334, 2004.

Fthenakis V.M., Kim H.C., Colli A., and Kirchsteiger C., Evaluation of Risks in the Life Cycle of Photovoltaics in a Comparative Context, 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, 4-8 September 2006.

Moskowitz P. and Fthenakis V., Toxic materials released from photovoltaic modules during fires; health risks, Solar Cells, 29, 63-71, 1990.

Sherwani, A.F., Usmani, J.A., & Varun. Life cycle assessment of solar PV based electricity generation systems: A review. Renewable and Sustainable Energy Reviews. 14, 540-544, 2010.

Zayed, J; Philippe, S (2009-08). "Acute Oral and Inhalation Toxicities in Rats With Cadmium Telluride" (PDF). *International journal of toxicology* (International Journal of Toxicology) **28** (4): 259–65. doi:10.1177/1091581809337630. PMID 19636069. http://ijt.sagepub.com/cgi/content/short/28/4/259.

Appendix B

Envirotemp FR3 Material Safety Data Sheet
&
Envirotemp FR3 Fluid – Frequently Asked Questions

Cooper Power Systems

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION

Envirotemp® FR3® fluid

Envirotemp FR3 fluid is a dielectric fluid intended for use as an insulation and cooling medium in electrical apparatus such as electrical distribution and power transformers.

Cooper Power Systems
1900 East North Street
Waukesha, Wisconsin 53188-3899 USA

Telephone: +01 262 524 3300
Internet: www.cooperpower.com

Emergency telephone (Chemtrec)
Inside USA: 800 424 9300
Outside USA: +01 703 527 3887

---

2. COMPOSITION/INFORMATION ON INGREDIENTS

Envirotemp FR3 fluid is a proprietary formulation using food-grade vegetable oils combined with performance-enhancing additives. All components are listed in the EINECS inventory.

Component	Proportion (wt%)
Vegetable oil	> 98.5
Antioxidant additive	< 1.0
Cold flow additive	< 1.0
Colorant	< 1.0

---

3. HAZARDS IDENTIFICATION

Envirotemp FR3 fluid is a preparation not classified as dangerous according to Directive 1999/45/EC. Not expected to cause a severe emergency hazard.

Routes of entry

Eyes: Contact may occur as a result of splash or exposure to mist conditions. May cause irritation and redness.

Skin: Typically non-irritating. In some case, a sensitization to vegetable oils may cause localized redness

Ingestion: May cause gastric irritation.

Inhalation: Exposure may occur as a result of mist exposure. May cause respiratory irritation.

Signs and symptoms of exposure: none known

Medical conditions generally aggravated by exposure: There is a very small risk for an allergic reaction to soybean oil in persons allergic to soybeans themselves.

---

4. FIRST AID MEASURES

Inhalation: If inhaled, remove affected person from exposure to mists.

Eye contact: For eye contact, flush the eyes immediately with large amounts of water with the eyelids held away from the eye to ensure thorough rinsing.

Skin contact: For skin contact, remove by washing with soap and water. Get medical attention if irritation persists.

Ingestion: If swallowed, observe for signs of stomach discomfort or nausea. If symptoms persist, seek medical help. Do not induce vomiting.

5. FIRE-FIGHTING MEASURES

Extinguishing media: CO_2 or dry chemical foam

Special fire fighting procedures: Use approved self-contained breathing apparatus with full facemask and full protective equipment in confined areas. Use water to keep fire-exposed containers cool. Water spray may be used to flush spills away from source of ignition. Application of water to flaming oil can cause spreading.

Unusual fire and explosion hazards: Slight when exposed to flame. Can react with oxidizing materials. Clay materials (Fuller's earth, oil dry products) saturated with Envirotemp FR3 fluid can, under certain conditions, undergo a slow oxidation that releases heat. If the heat so released cannot escape, it is possible that the temperature may increase and ignite combustible materials in close contact.

6. ACCIDENTAL RELEASE MEASURES

Steps to take in case material is released or spilled: Contain and control the leaks or spills with non-combustible absorbent materials such as sand, earth, vermiculite, or diatomaceous earth in drums for waste disposal. Prevent any material from entering drains or waterways. If the product contaminates waterways, rivers or drains, alert the relevant authorities in accordance with statutory procedures.

In the USA, spills into navigable waters must be reported to the National Response Center, 800-424-8802

7. HANDLING AND STORAGE

Precautions to take in handling and storage: Avoid extremes of temperature in storage. Store Envirotemp FR3 fluid in labeled, tightly closed containers in cool, dry, isolated and well-ventilated areas, away from sources of ignition or heat. To maintain fluid for intended use as an electrical insulating fluid, eliminate exposure to oxygen and moisture.

Intermediate bulk storage container (tote): Prolonged exposure to ultraviolet radiation (sunlight) may affect color.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure limit values:

	TWA (mg/m^3)	
	OSHA[1] PEL	ACGIH [2] TLV
Vegetable oil mists	–	10
Vegetable oil mists: total dust	15	–
Vegetable oil mists: respirable fraction	5	–

Hazardous Materials Identification System (HMIS):	Health	Flammability	Physical Hazard
	0	1	0

Respiratory protection: Vaporization is not expected at ambient temperature. Therefore, the need for respiratory protection is not anticipated under normal use conditions and with adequate ventilation. If elevated airborne concentrations above applicable workplace exposure levels are anticipated, a NIOSH-approved organic vapor respirator equipped with a dust/mist prefilter should be used. Protection factors vary depending upon the type of respirator used. Respirators should be used in accordance with OSHA requirements (29 CFR 1910.134). For extreme cases, use of approved supplied-air respiratory protection may be necessary.

Ventilation: General mechanical ventilation can be used to control or reduce airborne concentrations of oil.

Protective gloves: Use gloves constructed of chemical resistant materials such as neoprene or heavy nitrile rubber if frequent or prolonged contact is expected. Use heat-protective gloves when handling product at elevated temperatures.

[1] U.S. Occupational Health and Safety Administration

[2] American Conference of Governmental Industrial Hygienists

Eye protection: Wear safety glasses or goggles to prevent eye contact. Eye baths should be readily available in the area of handling Envirotemp FR3 fluid.

Other protective clothing or equipment: Wear regularly laundered coveralls or lab coat to minimize skin exposure.

Workplace hygienic practices: Wash with soap and water after contact. Avoid exposure to mists.

Environmental exposure controls: Have oil-absorbent materials easily available.

---

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and odor: clear light-green liquid with slight vegetable oil odor

pH: neutral

Closed cup flash point: 310 – 320°C

Autoignition temperature: 401 – 404°C

Boiling point: >360°C

Relative density (H_2O = 1): 0.92

Vapor pressure (mm Hg): < 0.01 @ 20°C

Pour point: -18 to -24°C

Vapor density (air = 1): n/a

Evaporation rate (butyl acetate = 1): nil

Solubility in water: negligible; < 0.1%

Volatile organic compounds: < 0.001 g/L

Viscosity: 33 – 35 mm^2/s at 40°C

Miscibility: mixes with other dielectric fluids except silicone

---

10. STABILITY AND REACTIVITY

Stability: Envirotemp FR3 fluid is stable under normal conditions of use.

Incompatibility (materials to avoid): Avoid contact with strong oxidizing agents.

Hazardous decomposition products: none

Hazardous Polymerization: will not occur

Stabilizers: not required

Hazardous exothermic reaction: Slight when exposed to flame; can react with oxidizing materials. Class III B liquid. Clay materials (Fuller's earth, oil dry products) saturated with Envirotemp FR3 fluid can, under certain conditions, undergo a slow oxidation that releases heat. If the heat so released cannot escape, it is possible that the temperature may increase and ignite combustible materials in close contact.

---

11. TOXICOLOGICAL INFORMATION

Carcinogenicity: none **NTP:** no **IARC monographs:** no **OSHA regulated:** no

Envirotemp FR3 fluid base oils are "generally recognized as safe" (GRAS) by the U.S. Food and Drug Administration and allowed for human consumption as a food and as a component that is allowed in contact with human food.

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12. ECOLOGICAL INFORMATION

Acute oral toxicity (OECD 420 - rats): LD_{50} >2000 mg/kg

Acute aquatic toxicity (OECD 203 - trout): LC_{50} >1000 mg/kg; NOAEC >1000 mg/kg

Aquatic biodegradation (OPPTS 835.3110): readily biodegradable, >99%

Biological oxidation demand (5-Day SM5210B): 250 ppm

Chemical oxygen demand (SM5220D): 560 ppm

BOD/COD ratio: 45%

Petroleum hydrocarbon content: none

Environmental physical hazard: Envirotemp FR3 fluid shares physical hazards common to all oils such as coating feathers, fur, and gills.

---

13. DISPOSAL CONSIDERATIONS

Recycling: Consult with local used oil recyclers, restaurant grease recyclers, fat rendering companies, or biodiesel producers.

Hazardous Waste: Envirotemp FR3 fluid itself, when discarded or disposed of, is not a hazardous waste. Envirotemp FR3 fluid from retrofilled electrical equipment may contain residues of earlier fluid(s) in such quantity as to qualify as a hazardous waste.

Disposal: Incinerate or landfill in accordance with local regulations. Do not pour into drains or waterways.

---

14. TRANSPORT INFORMATION

Harmonized System Tariff Classification (Schedule B): 1518.00.0000

National Motor Freight Classification (NMFC): 155250

Euro Tariff: 15 18 00 00 00

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15. REGULATORY INFORMATION

Envirotemp FR3 fluid itself, when discarded or disposed of, is not listed as a hazardous waste per 40 CFR 261 and is not a used oil per 40 CFR 279. Envirotemp FR3 fluid is a preparation not classified as dangerous according to Directive 1999/45/EC.

---

16. OTHER INFORMATION

Technical information available at the Cooper Power Systems website: www.cooperpower.com

This Material Safety Data Sheet has been prepared in order to help the users of Envirotemp FR3 fluid. The data contained herein is, to the best of our knowledge, accurate as of the date of preparation of this sheet.

Effective Date: June 19, 2008

Patrick McShane
Global Technology Leader – Dielectric Fluids

Envirotemp® FR3™ Fluid - Frequently Asked Questions (FAQs)

This resource provides answers to frequently asked questions about Envirotemp® FR3™ Fluid regarding Fire Safety, Environmental, Performance and Commercial considerations.

Fire Safety FAQs

Q: Why do you claim that FR3™ fluid is so much safer than mineral oil? It can still burn, can't it?
A: Simply put, mineral oil transformer fires are a daily occurrence. Even a single incident can cost property owners tens of millions of dollars. CPS has never received a report of an oil fire involving any of our fire-resistant fluids.

While the energy from electrical arcing often ignites mineral oil, (fire point approx. 160° C), numerous tests by FM Global show that the same arc energy is not sufficient to ignite dielectric coolants with fire points at or above 300° C.

With the highest flash and fire points of any dielectric coolant, (330° and 360° C, respectively). FM considers it extremely unlikely for a pool fire to develop for FR3™ fluid. They're so confident that they have reduced recommended minimum clearances to as low as 3 feet.

Q: What other independent agencies have verified the fire safety of FR3™ fluid?
A: Test results from Factory Mutual Global Underwriters Laboratories, Doble Engineering and the US EPA have also verified the key fire safety properties of FR3™ fluid. It is an FM Approved, UL Classified fluid for indoor and outdoor installations per NEC 450-23 and meets the criteria as a "high fire point fluid" per NESC.

Q: But aren't dry types safer?
A: Not according to fire incident reports. Dry types, including cast resins, can and have failed catastrophically due to flammable vapors produced by the vaporization of metal. Furthermore, dry types do not have the preventive maintenance tool of DGA (Dissolved Gas Analysis) to predict unseen problems. As mentioned above, there have been no reported oil fires involving any CPS fire-resistant fluid in its quarter century of experience. And units that meet the UL and FM listed transformer requirements help prevent tank rupture from internal arcing as well.

Q: Does FR3™ fluid auto-ignite if it reaches its 360° C fire point?
A: No, even at 360° C it will not ignite without an external ignition source. It is extremely unlikely for the dielectric coolant in a severely overloaded transformer to exceed 130° C, so the margin of safety is very high.

Q: After retrofilling a transformer, what fire safety concerns should remain due to residual mineral oil?
A: As incredible as it seems, even with a contamination of up to 7.5% mineral oil, FR3™ fluid key properties remain unaffected and maintains a fire point of over 350° C, including maintaining a fire point rating of over 350°C. (Proper retrofilling should result in less than 5% residual mineral oil.)

Q: Does the use of FR3™ fluid eliminate the need for fire safeguards that are required when using mineral oil?
A: Typically yes, and the savings can be very substantial. This includes protective barriers like safety walls, as well as deluge systems and other fire suppression equipment. It also includes significantly reducing the minimum clearance distance between transformers and buildings.

Environmental FAQs

Q: Our environmental compliance department has advised us that the US EPA considers all oil to be equal - with common compliance requirements. Is that right?

A: Not exactly. There are different requirements for different jurisdictions of the EPA. For example, FR3™ fluid would be exempt from the Federal Regulation of Used Oils. Furthermore, within the 2002 edition of the SPCC (Spill Prevention Control and Countermeasures), two of the three key requirements are the same: "volume threshold for compliance" and the "minimum response time." The EPA is considering further revisions as well as different remediation actions depending on the volume and site specifics. Remember: SPCC is only applicable to installations where there is exposure to navigable waters.

Q: Why should my company use FR3™ fluid in place of mineral oil if there is no significant relief from the US EPA SPCC rules.

A: Because it is the right and responsible thing to do. Since FR3™ fluid-filled transformers have a favorable life cycle cost and a virtually non-existent potential for oil fires, why not use a fluid that is much more friendly to the environment? In a very sensitive OECD test method, trout fry were exposed to FR3™ fluid for 96 hours; the mortality rate was zero. The biodegradability rate meets the highest EPA classification, while mineral oil has the lowest. The US EPA has verified our environmental claims. Their document states: "These select mineral oil-based fluids listed a hydrotreated light naphthenic petroleum distillate, which is an IARC confirmed carcinogen."

Because FR3™ fluid is biobased and made of edible oils, it meets the intent of the Edible Oil Act of 1995, this supports current and future environmental regulatory relief. However, spill reporting and remediation may still be required by the authorities having jurisdiction, particularly for large volume spills into surface water.

Q: One of the conditions needed to meet SPCC requirements for remediation is that there must be a visible iridescent sheen on the water. Does FR3™ fluid create a sheen similar to petroleum oils?

A: FR3™ fluid does not create an iridescent sheen. Unlike mineral oil, it also tends to break up and disperse rather than maintaining a large-area sheen; it also biodegrades much faster than mineral oil. FR3™ fluid is so safe that fish farms actually use similar edible vegetable oils for feeding.

Q: Which environmental tests for FR3™ fluid were verified by the US EPA?

Table 1: Evaluations of Envirotemp® FR3™ fluid environmental properties and associated test methods.

ENVIRONMENTAL HAZARD

Property	Test	Method
Toxicity	Acute Aquatic Acute Lethality using Rainbow Trout	OECD 203 Environment Canada
Biodegradation	Aquatic Biodegradation Aerobic Aquatic Biodegradation Ready Biodegradation Biochemical Oxygen Demand (BOD5)	CEC L-33-A-93 OPPTS 835.3100 OPPTS 835.3110 SM 5210B

SITE ASSESSMENT

Property / Test	Method
Total Petroleum Hydrocarbons Fuel Hydrocarbons	 SW-846 Modified 8015B
Total Recoverable Petroleum Hydrocarbons Spectrophotometric	 600/4-79/020 418.1
Total Recoverable Oil and Grease Gravimetric Spectrophotometric	 600/4-79/020 413.1
Target Compound List	600/4-79/020 413.2
Semi-Volatile Organics Volatile Organics	SW-846 Method 8270C SW-846 Method 8260B
Toxicity Characteristic Leaching Procedure 7000 series 3510, 8270 5030, 8260	 SW-846 Method 1311 SW-846 Method 1311 SW-846 Method 1311
Total Threshold Limit Concentration 7000 series	 SW-846 Methods 6010

ASSESMENT-RELATED PROPERTIES

Property	Test	Method
Heat of Combustion		ASTM D240
Ignitability	Pensky-Martens Flash Point Setaflash Flash Point	SW-846 Method 1010 SW-846 Method 1020A
Total Organic Halides (TOX)	Extractable Organic Halides	SW-846 Method 9020B
Leachable Fluoride		600/4-79/020 340.2
Cyanides	Reactive Cyanide Cyanides in Waste	SW-846 7.3.3 ASTM D5049
Sulfides	Reactive Sulfide Sulfides in Waste	W-846 7.3.4 ASTM D4978
Soil and Waste Ph		SW-846 Method 9045C
Specific Gravity		SM 2710F
Odor, Color, Appearance		ASTM D4979

Q: Do any states provide preferential relief for FR3™ fluid spills that are not under SPCC jurisdiction?
A: Most states do not officially address edible oil spills to soil. Several use "total petroleum hydrocarbon" (TPH) levels as the basis for remediation requirements. FR3™ does not register or test as a TPH. Mineral oil does. While several state agencies will selectively consider allowing FR3™ fluid spills to biodegrade naturally, there are some states that regulate edible oils and petroleum products equally.

Q: Is there anything in FR3™ fluid that would negatively impact ground water quality?
A: Although it's unlikely that the fluid would ever reach ground water, because of viscosity and other characteristics, there is nothing that will significantly affect the quality of the ground water. In fact, the USDA has conducted studies using vegetable oils to remediate fertilizer-contaminated well water.

Q: How long will it take for FR3™ fluid to "disappear" if it is spilled?
A: In EPA testing, FR3™ fluid completely biodegraded within 28 days. It's important to note however, as with any biodegradable material, biodegradation rate is dependent upon climatic and environmental conditions.

Q: Does the FM Global Loss Prevention Sheet for transformers, actually differentiate containment requirements for FR3™ fluid?

A: Yes, with FR3™ fluid, as well as other fluids that are non-toxic and quick to biodegrade, FM allows a doubling of the threshold volume of other fire-resistant fluids before containment is required (sites under SPCC jurisdiction excluded). The US EPA "ETV" logo on FR3™ fluid-filled transformers assures compliance with the FM requirement.

Performance FAQs

Q: I've heard that the oxidation stability of vegetable oils used in transformers is generally lower than mineral oil. Is this a significant issue?
A: Thin films of vegetable oil, exposed to heat and air flow, do oxidize much faster than mineral oil. However, in ANSI/IEEE standard designs (not the free breathing type often used in European designs) the exposure to oxygen is insignificant. Additionally, the oxidation byproducts of mineral oil are much more harmful to the performance of a transformer than those from vegetable oil. FR3™ fluid also contains a food grade preservative. Accelerated life tests, Doble Engineering PFVO tests and data from the field all show FR3™ fluid very suitable for the application.

For more details, please refer to Reference Information entitled Oxidation Stability of Envirotemp(r) FR3™ fluid, CPS Document R900-20-2

Q: If FR3™ fluid biodegrades so quickly, should I be concerned about the potential for this material breaking down inside the transformer during a normal product life span?
A: We have no more concern for this than we do with mineral oil. Even though mineral oil has a much slower biodegradation rate, it also biodegrades. Even with transformers lasting 40 plus years, biodegradation has not been a problem. The internal conditions for biodegradation are lacking: this includes free water, unlimited oxygen, oil-eating microbes and thin layers of fluid.

Q: I've heard that FR3™ fluid-filled transformers typically produce higher transformer insulation power factor readings than mineral oil filled units. Is this a significant concern?
A: No. Insulation power factor readings of new mineral oil units are sometimes used as an indicator of moisture content in the insulating paper. For operating mineral-oil-filled transformers, power factor readings are an indicator of the amount of polar contaminants within the insulation system.

It's important to remember however, that the energy loss associated with power factor is insignificant compared to core and winding losses. The more important application is comparing significant changes between power factor readings over time.

Because natural ester fluids have inherently higher dissipation factor values than mineral oils, the insulation system using the esters will result in inherently higher power factor values as well. If a power unit has power factor (p.f.) of 0.5% in mineral oil, the resulting p.f. with FR3™ fluid would be approximately double that value. The difference with distribution transformers would be smaller. The industry first experienced inherently higher power factors with askeral transformers; p.f. values on these units would often reach into the mid-teens, even for distribution with our performance issues class.

For more details, please refer to the Reference Information entitled: Power Factor Discussion, CPS Document R900-20-1.

Q: I've heard a lot about transformer life extension using FR3™ fluid. How can it do that? What proof do you have?
A: The consensus in the industry is that there is a direct correlation between transformer life and paper life. Paper aging rate is primarily related to operating temperature. When paper ages, it produces moisture and de-polymerizes. This results in reduced dielectric performance and weaker physical strength. Once this happens, the transformer is less tolerant to voltage impulses and through-faults. Moisture in paper increases the rate of degradation.

FR3™ fluid slows down the aging process in several ways. First, FR3™ fluid extracts more moisture from the paper than mineral oil, which has a much higher moisture saturation value. Second, FR3™ fluid removes dissolved moisture by hydrolysis. Finally, the by-product of that process actually provides additional protection to the aging paper through a *process called transesterification. FR3™ fluid essentially takes the compounding effect of moisture out of the aging equation.*

IEEE C57 Standards indicate that when a new insulation system is proposed, it must pass the accelerated life tests of C57.100. The standard includes a full scale test using multiple transformers and a small scale test using multiple samples. The results of this testing showed the insulation system with FR3™ fluid out-lasted the mineral oil system (4 to 8 times, at the same operating temperature). Peer-reviewed technical papers on the remarkable results of both tests are published by IEEE and are available from CPS.

Q: Is it correct that FR3™ fluid has limitations due to cold temperature operation?
A: It depends on the issue. With a -21° C pour point (similar to R-Temp(r) fluid), FR3™ fluid has higher temperature limits on power switching than standard mineral oil. Typical limits when the switching contacts are immersed in the coolant are -10° C.

Increased viscosity is another issue that needs to be addressed when handling FR3™ fluid at colder temperatures. Cold starting units, with continuous pumping as well as physical jarring of de-energized transformers, should be avoided when temperatures are below -21 °C. On the other hand, full load cold start of distribution transformers, chilled to temperatures between -40° C and -30° C, showed no signs of thermal runaway. R-Temp(r) fluid units have been functioning for Arco Alaska, near the Arctic Circle, without any reported problems. Many FR3™ fluid units have also been operating in very cold climates with no reported problems. For operation of power transformers with LTCs in very cold weather (-10 °C), we recommend the use of our synthetic ester fluid, Envirotemp(r) 200 fluid in the LTC chamber. The pour point of Envirotemp 200 fluid is below -50° C.

Q: I don't need or want longer life from my transformers. I want to drive them harder. Can I?
A: Probably. Our proven improved paper aging rate allows a choice between longer life, higher overloadability, or a combination. Based on the data obtained from the C57.100 tests described above, the temperature rise for equivalent life between the two insulation systems is 21° C.

Assuming all the other materials can withstand the higher operating temperature, and there is no practical danger to the public regarding touch temperature, a unit designed with FR3™ fluid can run at an 86° C rise vs. a 65° C mineral oil designed unit. This represents approximately a 20% increase in its rating.

For oil retrofills, the increase is somewhat reduced due to the higher viscosity of FR3 fluid. The increase in rating will vary from approximately 14% to 19%, depending on the transformer size and design.

Q: Does the aging rate of insulating paper in older mineral oil-filled transformers change after retrofilling? And, is the aging rate improvement comparable to that seen in accelerated aging tests using new units and paper?
A: Yes, the C57.100 small scale tests were performed using paper initially aged in mineral oil and then further aged in FR3™ fluid. The aging rate changed immediately and the water moisture content of the paper dropped to a low level within 500 hours.

Q: How much life extension can I expect after retrofilling with FR3™ fluid?
A: While there can be no exact answer to the question due to many variables, we do know that the paper aging rate will reduce by a factor between 4 to 8 times. We also know that the moisture level of the paper will immediately start to drop, improving the dielectric performance of the paper. After reviewing our aging data, a major IOU determined that, on average, the remaining life will at least double.

Q: Are there other benefits in retrofilling besides insulation life extension?
A: Yes, particularly in the areas of enhanced fire safety and improved environmental performance. In comparison to mineral-oil-filled transformers, FM Global recently reduced the separation distances as little as one tenth. This is based on their contention that a pool-oil fire is all but impossible with FR3™ fluid. Other advantages over mineral oil include reduced tendencies for coking, gassing and sludging.

Q: What is the recommended procedure for retrofilling?
A: The answer depends on the size, voltage, type of transformer and permissible down time. We do recommend contracting the services of a certified power transformer retrofiller, such as Waukesha Electric Systems Services for medium and large units.

For small power units, distribution units and for the initial retrofills, at least, we recommend contacting CPS Services. Those directly involved with the retrofilling operation should become familiar with both the Envirotemp® FR3™ Storage and Handling Guide, Bulletin No. 99048, and the Envirotemp® FR3™ Retrofilling Guide, Bulletin No. 00046.

Q: How does CPS warrant retrofills with FR3™ fluid?
A: Currently we offer our standard warranty which guarantees that our fluid will meet its acceptance values. The condition of the transformer and the retrofilling process determines the success of the retrofill. CPS will also work with you to structure extended warranties for a premium. Contact the Fluids Products Group for additional information and updates.

Q: How does FR3™ fluid perform in LTCs? Are any special precautions recommended?
A: FR3™ fluid works well as an LTC fluid under most conditions. It has been tested and approved for use in the CPS Quik Drive™ LTCs used in voltage regulators. Tests, under load break operations, have shown FR3™ fluid to better maintain its dielectric strength than mineral oil.

There are two precautions: At temperatures below -10° C, the LTC may not meet its ratings. Either a temperature sensitive lockout or the application of the synthetic ester, E-200 is recommended. The other issue is that many LTC's, especially the modern units, tend to be free breathers. We strongly recommend using E-200 for such designs and making sure that a moisture desiccant is provided and properly maintained for either fluid.

Q: If FR3™ reduces paper aging, why not increase the allowable transformer hot spot temperature rise for new units?
A: The IEEE standard for distribution transformers is 65° C rise, and in some cases 55/65° C. Since 1999, CPS has offered FR3™ fluid-filled transformers for both ratings. In 2004, CPS will offer higher-rise Envirotran™ products for use in substation and pole applications where there will be no public contact potential. Even though IEEE testing with FR3 fluid indicates that paper ages the same rate at 21° C higher temperatures than in mineral oil, other materials need to be analyzed to insure they can also withstand the higher operating temperatures.

Q: Can we use the same equipment for handling and processing mineral oil and FR3™ fluid? Are the fluids miscible? Are any special precautions recommended?
A: FR3™ fluid is miscible with mineral oil and does not create the problems associated with trace contamination of silicone in mineral oil. While it's obviously advisable to totally avoid blending of dielectric materials, it takes more than 7% mineral oil contamination to reduce the fire point of FR3™ fluid. It's especially important to avoid cross contamination to maintain the exceptional environmental properties of FR3™ fluid. Flushing the mineral oil processing equipment and hoses with FR3™ fluid is recommended. FR3™ fluid is also miscible with synthetic esters, synthetic hydrocarbons (PAOs) and R-Temp® fluid.

Refer to Bulletin 99048, Envirotemp® FR3™ Fluid Storage and Handling Guide, for additional information.

Q: Is FR3™ fluid compatible with the other materials used in the transformer?
A: To date, we've concluded that FR3™ fluid has equal or less effect on conventional transformer materials than mineral oil. A power transformer manufacturer has reported similar results with their materials. Aged, brittle gaskets should be replaced whenever practical. If not, additional tightening may be required to seal the gaskets.

Q: Some of our power transformers have conservators that are free breathing design. Can we retrofill such units with FR3™ fluid?
A: Although we've successfully used FR3™ fluid in some free-breathing transformers for over 5 years, we don't advocate this practice until we have further data. Units with free-breathing conservators should be retrofitted with bladders.

Q: Can FR3™ fluid be used to retrofill an askarel (PCB)-filled transformer?
A: Yes, successful retrofills of askarel transformers have been reported. However, due to the leaching of residual PCBs, the environmental attributes of pure FR3™ fluid are impacted and if enough PCBs leach from the paper, the unit may still be classified as a PCB transformer. Also, if the unit was specifically designed to use the low-viscosity askeral material, resulting temperature rise (at a given load) will be higher than that of a retrofilled mineral oil unit.

Q: We rely on DGA (Dissolved Gas Analysis) as a key preventive maintenance tool. Can I use the existing DGA methods with FR3™ fluid?
A: DGA has proven effective with FR3™ fluid for condition diagnostics. The same fault gasses are produced. IEEE C57.104 DGA Guide is applicable, particularly the "condition" and "key gases" methods. Since we do not have a "reported field failures" database, or ratio methods for determining type of failure, these diagnostic processes are not recommended at this time. The same sampling methods and equipment are appropriate for FR3™ fluid, although the "headspace" is easier and preferred over the "direct injection" equipment. Since we do not have any field failures to obtain data from, the ratio diagnostic methods can not be verified as applicable for FR3™ fluid.

Commercial FAQs

Q: We are not allowed to specify a single source for transformers. Will you sell FR3™ fluid to other transformer manufacturers?
A: Yes, just as we have sold R-Temp® fluid to other manufacturers since 1977.

Q: We are a technologically conservative company that's never comfortable being first. Do you have many current users? When were the first units installed?
A: The current users list includes hundreds of utilities (investor-owned, public power and rural co-op) as well as governmental, commercial, industrial and institutional end users. Thousands of new and retrofilled units, from small single phase poles to substation power transformers, have been performing flawlessly. While the first field trials began in 1996, the fluid has been successfully applied since 1999 in electrical devices from transformers to transformer/rectifier sets and switchgear to voltage regulators.

Q: Why is FR3™ fluid so expensive compared to mineral oil?
A: To minimize health and environmental concerns, the base oil is a food-grade product. Currently, production costs to make vegetable oil are higher due to harvesting, extraction and refining costs. Our current production volume also prevents us from approximating the economies of scale that apply to petroleum products. When you consider the unique advantages, the total life cycle costs still make FR3™ fluid a bargain.

Q: How can I be sure of product availability?
A: Because the base oils used in FR3™ fluid are "USA commodity oils," there is no domestic shortage. The additives are also USA produced. CPS has been in the specialty dielectric fluids business since 1976. CPS fluids has made product availability a top priority. We have never missed a shipment deadline based on our standard lead times.

In addition, CPS maintains a sufficient inventory of FR3™ fluid to provide for emergency needs and short shipment requirements. Volumes under 1,000 gallons can be express shipped if necessary.

Q: I understand the technical advantages of the product, but expect management resistance when presenting a product with a potentially higher first cost. What tips can you provide?
A: Using net present value calculations, you can easily make a strong financial case for converting to FR3™ fluid. In fact, the payback period is usually less than 24 months. Cooper Power Systems, in collaboration with our customers, has developed a financial calculator to demonstrate the financial value of FR3™ fluid. This tool is available on CD-ROM and via the web.

Appendix C

Material Safety Data Sheet

Q-Cell Solar PV Modules
12-01-2020

PRODUCT SAFETY DATA SHEET

Q CELLS SOLAR PV MODULES ARE ARTICLES AS DEFINED BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION HAZARD COMMUNICATION STANDARD (HCS), 29 C.F.R. § 1910.1200 AND ARE EXEMPT FROM THE LABELING AND SAFETY DATA SHEETS (SDS) REQUIREMENTS OF THE STANDARD.

Q CELLS provides this product safety data sheet only for convenience of interested parties in the United States of America who are used to the format of safety data sheets in order to assess the product safety. This product safety data sheet does not replace any other documents provided by Q CELLS such as Safety Information, Installation and Operation Manual, Packaging and Transport Information, Product Data Sheet as well as Warranty Terms of the respective product.

1. SECTION: IDENTIFICATION

Solar PV modules convert light into electricity. Light-sensitive cells are electrically interconnected in series and sealed between glass and plastic foils for this purpose. This product safety data sheet is applicable to the following solar PV modules of the Q CELLS brand made by Hanwha Q CELLS America Inc.:

- Q.PEAK DUO-G5, Q.PEAK DUO BLK-G5, Q.PEAK DUO L-G5, Q.PEAK DUO-G5.X, Q.PEAK DUO BLK-G5.X, Q.PEAK DUO L-G5.X,
- Q.PEAK DUO-G6, Q.PEAK DUO BLK-G6, Q.PEAK DUO L-G6, Q.PEAK DUO-G6.X, Q.PEAK DUO BLK-G6.X, Q.PEAK DUO L-G6.X,
- Q.PEAK DUO-G7, Q.PEAK DUO BLK-G7, Q.PEAK DUO L-G7, Q.PEAK DUO-G7.X, Q.PEAK DUO BLK-G7.X, Q.PEAK DUO L-G7.X,
- Q.PEAK DUO-G8, Q.PEAK DUO BLK-G8, Q.PEAK DUO L-G8, Q.PEAK DUO-G8.X, Q.PEAK DUO BLK-G8.X, Q.PEAK DUO L-G8.X
- Q.PEAK DUO ML-G9, Q.PEAK DUO BLK ML-G9, Q.PEAK DUO XL-G9, Q.PEAK DUO ML-G9.X, Q.PEAK DUO BLK ML-G9.X, Q.PEAK DUO XL-G9.X

Minor variations within the product families listed above can be identified by a versioning system which replaces character “X” with numerals of either “1”, “2” or “3” to form G8.1, G6.2 or G7.3 for example. All of these variants as well as the ones with additional suffixes “/TAA” and / or “+” are covered by this product safety data sheet. This is also true for B-grade modules which have minor optical imperfections. Product names of these replace “Q.” with “B.LINE”. B-grade modules of Q.PEAK DUO L-G6.2 are named B.LINE PEAK DUO L-G6.2 for example.

Responsible Party as Importer:
Name: Hanwha Q CELLS America Inc.
Address: 400 Spectrum Center Drive, Suite 1400, Irvine, CA 92618, USA
Phone: 1 949 748 59 96

2. SECTION: IDENTIFICATION OF SAFETY RISKS (HAZARDS IDENTIFICATION)

Q CELLS solar PV modules do not pose any risk of hazardous chemicals. Hazard symbols and precautionary hazard statements for hazardous chemicals are not applicable. No symptoms or effects – neither acute nor delayed – have to be expected when Q CELLS solar PV modules are handled as stipulated in the Installation and Operation Manual. Q CELLS provides a Safety Information sheet with all modules shipments. This document contains detailed risk statements and recommendations for installation and operation. Before installing the module, read the Installation and Operation Manual for Q CELLS modules carefully. You can obtain the complete Installation and Operation Manual from your retailer.
Attention: Only qualified and authorized specialists may install modules and put them into operation. Keep children and unauthorized persons away from the modules.
Risks:
- Risk of death from electrocution! Solar modules generate electricity and are energized as soon as they are exposed to light.
- In rare cases, solar PV modules – as any other electrical device – can cause fire due to worn electrical contacts which result in electrical arching.
- Solar PV modules can reach high temperatures which can cause skin burns.
- Sharp edges, corners and broken glass can cause injuries.
- Solar PV modules can cause Injuries due to their weight.
    - Falling solar PV modules can cause injuries.

- Lifting solar PV modules can cause injuries.

For precautionary statements, please refer to the Installation and Operations Manual of the respective product.

MISUSE OR INCORRECT USE OF SOLAR MODULES VOIDS THE LIMITED WARRANTY AND MAY CREATE A SAFETY HAZARD AND RISK PROPERTY DAMAGE. THIS INCLUDES IMPROPER INSTALLATION OR CONFIGURATION, IMPROPER MAINTENANCE, UNINTENDED USE, AND UNAUTHORIZED MODIFICATION.

3. SECTION: COMPOSITION / INFORMATION ON INGREDIENTS

Safety data sheets are only required for hazardous chemicals covered by the Hazard Communication Standard (HCS). Solar PV modules made by Q CELLS are not covered by HCS. The following table provides an overview of materials solar PV modules by Q CELLS are made of. The values given for the share of weight are targets and can vary for the products covered by this Product Safety Data Sheet.

Component	Material	Total Share	Remark
Frame	Aluminum	8 % – 16 %	not hazardous
	Silicone	< 2 %	not hazardous, see section 8
Laminate	Glass	60 % – 80 %	not hazardous
	Plastics (EVA, PET, PE, PPE, PC)	8 % – 16 %	no hazards known
	Silicon	2 % – 4 %	not hazardous
	Metals (Aluminum, Copper, Tin)	0.5 % – 2.5 %	not hazardous
	Lead	< 0,1 %	hazardous
	Silver	< 0,05 %	not hazardous

4. SECTION: FIRST-AID MEASURES

In case of electrocution:

- Always protect yourself by taking all necessary safety precautions before rescuing persons injured.
- **Attention:** Stay away from sources of high voltage and leave the rescue to qualified personnel with appropriate personal protection equipment!
- Call emergency rescue services.
- Do not touch live parts. Qualified personnel should shut down the PV system as far as possible – e.g. disconnect the modules at the inverter before uncovering any live electrical parts. Be sure to observe the specified time intervals after switching off the inverter. High voltage components need time to discharge. Follow OSHA requirements for control of hazardous energy at 29 C.F.R. § 1910.147.
- In the event a person is electrocuted or affected by electrical energy of the solar PV module, CALL 911. Before attempting rescue, SHUTDOWN THE POWER SOURCE.
- Remove the victim from the power source using only insulated tools ONLY IF CONTACT WITH LIVE ELECTRICAL COMPONENTS CAN BE PREVENTED.
- Carefully move the injured from the zone of danger.
- After moving to a safe location, check heartbeat, respiration and consciousness of the injured person.
- Apply appropriate life-saving measures (CPR) accordingly before taking care of minor injuries.
- Consult a medical professional even if there are no visible injuries.
  - Flush thermal skin burns caused by touching hot surfaces of solar PV modules with cool water. Consult a medical professional.
  - Injuries due to sharp edges, corners and broken glass need to be appropriately treated. Consult a medical professional.
  - Other types of injuries need to be treated appropriately as well. Consult a medical professional.

5. SECTION: FIRE-FIGHTING MEASURES

- Q CELLS solar PV modules are fire rated as Class C according to IEC and UL 1703 / UL 61730 as well as Type 1 and 2 according to UL 1703 / UL 61730.
- Q CELLS solar PV modules are extensively tested at the factory to ensure electrical safety of the product before shipment.
- In rare cases, solar PV modules – as any other electrical device – can cause fire due to worn electrical contacts which result in electrical arching.
- In case solar PV modules which are not part of an array are on fire, USE FIRE EXTINGUISHERS RATED FOR ELECTRICAL EQUIPMENT, Class C.
- IN CASE A SOLAR PV MODULE ARRAY IS PRESENT, ANY FIRE SHOULD ONLY BE FOUGHT BY PROFESSIONAL FIREFIGHTERS. FIREFIGHTERS NEED TO TAKE PRECAUTIONS FOR ELECTRICAL VOLTAGES UP TO 1,500 VOLTS (DC).
- Some components of the modules can burn. Potential combustion products include oxides of carbon, nitrogen and silicon.
- In case of prolonged fire, solar PV modules may lose their structural integrity.

General recommendations from the below-mentioned reports:
- Fire service personnel should follow their normal tactics and strategies at structure fires involving solar power systems, but do so with awareness and understanding of exposure to energized electrical equipment. Emergency response personnel should operate normally, and approach this subject area with awareness, caution, and understanding to assure that conditions are maintained as safely as possible.
- Care must be exercised during all operations, both interior and exterior.
- Responding personnel must stay back from the roofline in the event modules or sections of an array may slide off the roof.
- Contacting a local professional PV installation company should be considered to mitigate potential hazards.
- Turning off an array is not as simple as opening a disconnect switch. As long as the array is illuminated, parts of the system will remain energized.
- When illuminated by artificial light sources such as fire department light trucks or an exposure fire, PV systems are capable of producing electrical power sufficient to cause inability to let go from electricity as a result of stimulation of muscle tissue, also known as lock-on hazard.
- Firefighting foam should not be relied upon to block light.
- The electric shock hazard due to application of water is dependent on voltage, water conductivity, distance and spray pattern.
- It is recommendable to fight fire with water instead of foam if a PV system is present. Salt water should not be used.
- Firefighter's gloves and boots afford limited protection against electrical shock provided the insulating surface is intact and dry. They should not be considered equivalent to electrical personal protection equipment.

Readers interested in more details may refer to the following reports:
- National Fire Protection Association, Fire Protection Research Foundation report "Fire Fighter Safety and Emergency Response for Solar Power Systems" issued May 2010, revised October 2013
- Important recommendations from a report called "Firefighter Safety and Photovoltaic Installations Research Project" issued by Underwriters Laboratories on November 29, 2011

6. SECTION: ACCIDENTAL RELEASE MEASURES

This section is not applicable.

7. SECTION: HANDLING AND STORAGE

Before installing the module, read the Installation and Operation Manual for Q CELLS modules carefully. Noncompliance with the instructions may result in damage and physical injury or death. Only qualified and authorized specialists may install modules and put them into operation. You can obtain the complete installation manual from your retailer. Details about transport and storage of palletized Q CELLS solar PV modules can be found in the Packaging and Transport Information of the respective module type.

Storage, transport and unpacking:
- Store the module dry, well-ventilated and properly secured. The original packaging is not weatherproof.
- Always transport the module in its original packaging.
- Do not stack the modules. This prevents damage of the junction box.
- The module is made of glass. Take great care when unpacking, storing and transporting it.
- Do not subject the module glass to any mechanical stress (e.g. through torsion or deflection). Do not step on the module or place any objects onto the module.
- Protect both sides of the module against scratching and other damage.
- Carry the module by holding the edges with both hands, or use a glass suction lifter.
- Never lift or carry the module using the module junction box or wiring. Avoid pulling on the wiring at all costs.

8. SECTION: EXPOSURE CONTROLS / PERSONAL PROTECTION

Before installing the module, read the Installation and Operation Manual carefully. Noncompliance with the instructions may result in damage and physical injury. Only qualified and authorized specialists may install modules and put them into operation. You can obtain the complete installation manual from your retailer.

- Please follow the valid national regulations and safety guidelines for the installation of electrical devices and systems.
- Please make sure to take all necessary safety precautions.
- Ensure that all personnel are aware of and adhere to accident-prevention and safety regulations.
- For handling of modules wear suitable protective gloves.
- Do not install damaged modules. Ensure that all electrical components are in a proper, dry, and safe condition.
- Do not modify the module (e.g. do not drill any additional holes). Never open the junction box.
- Ensure that modules and tools are not subject to moisture or rain at any time during installation. Only use dry, insulated tools for electrical work.
- Only connect cables with plugs. Ensure for a tight connection between the plugs. Plugs click together audibly.
- Cover the modules with an opaque material during installation. Cover the modules to be disconnected.

Silicones used in manufacturing release methanol during curing. Once cured, no additional methanol is released during use. Small amounts of these chemicals may be present in shipping cartons. Upon receipt, open container in a well-ventilated location and allow to stand for 5 minutes before removing units from cartons. Exposures above recommended limits for methanol of 200 ppm eight-hour time-weighted-average (TWA) will not occur.

9. SECTION: PHYSICAL AND CHEMICAL PROPERTIES

- Physical state: solid
- Voltage: refer to data sheet (below 50 volts for a single module)

Attention: Voltage of single modules add up when modules are electrically connected in series. Q CELLS solar PV modules are designed and certified for voltages up to 1,000 volts or even up to 1,500 volts. Connection of modules in series is only permitted up to the maximum system voltage as listed in the applicable data sheet.

- Weight: refer to data sheet
- Solubility in water: insoluble in water

PRODUCT SAFETY DATA SHEET

10. SECTION: STABILITY AND REACTIVITY

Under normal operating conditions as specified in the Product Data Sheet, Q CELLS solar PV modules are chemically stable.

- Q CELLS solar PV modules are tested for salt spray and ammonia resistance according to IEC 61701 and IEC 62716, respectively.
- Q CELLS solar PV modules support ambient operating temperatures from −40 °C to +85 °C (−40 °F to +185 °F).
- Do not install modules above 13.120 ft (4000 m) altitude above sea level.
- Some components of the modules can burn. Potential combustion products include oxides of carbon, nitrogen and silicon.
- Do not scratch off dirt. Use a soft cellulose cloth or sponge to carefully wipe off stubborn dirt. Do not use micro fleece wool or cotton cloths.
- Rinse dirt off with lukewarm water (dust, leaves, etc.)
- Use an alcohol based glass cleaner. Do not use abrasive detergents or tensides.
- Isopropyl alcohol (IPA) can be used selectively to remove stubborn dirt and stains within one hour after it appeared.
- Follow the safety guidelines provided by the IPA manufacturer.
- Do not let IPA run down between the module and the frame or into the module edges.

11. SECTION: TOXICOLOGICAL INFORMATION

Small amounts of methanol may be present inside shipping cartons. Open cartons and allow to vent before removing units. No exposure to hazardous chemicals will occur when the units are in use.

12. SECTION: ECOLOGICAL INFORMATION

Q CELLS solar PV modules are designed to withstand outdoor operating conditions for 25 years. Biodegradation is not expected due to high chemical stability of the components.

13. SECTION: DISPOSAL CONSIDERATIONS

Q CELLS solar PV modules should be recycled rather than dumped in a landfill. Raw materials of the product can be recovered by recycling companies. Disposal must be in accordance with national and local laws and regulations for electric / electronic waste.

14. SECTION: TRANSPORT INFORMATION

Q CELLS solar PV modules can be shipped via standardized container freight. Regulations for hazardous goods do not apply. For further details, please refer to the Packaging and Transport Information which can be provided as a separate document by Q CELLS.

15. SECTION: REGULATORY INFORMATION

- Q CELLS solar PV modules are tested according to international standards IEC 61215, IEC 61730 as well as US standards UL 1703 / UL 61730.
- Please refer to the Installation and Operation Manual and Product Data Sheet of the respective Q CELLS solar PV module.

16. SECTION: OTHER INFORMATION

- Date of initial creation of this product safety data sheet: July 1, 2016
- Date of last revision: December 01, 2020

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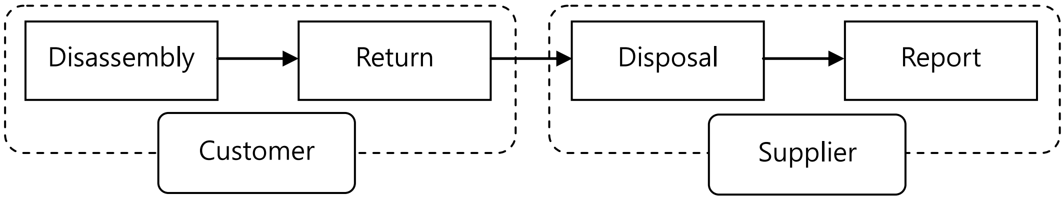
Appendix D

Battery Recycle Policy of Samsung SDI
Battery Material Safety Data Sheet
Fire Suppression Spec Sheets (Apollo, Kentec Electronics, Q-Light, System Sensor)

Appendix A. Disposal Procedures

Article 1. Responsible for Disposal

1. Responsibilities of disposal of ESS are up to customer.
2. Customer can require disposal to Supplier and Supplier shall ask Customer to pay for the disposal.
   Supplier shall send a written notice to customer when disposal of ESS is complete.
   A. Customer : Disassemble the product for disposal and return the product.
      Customer can require disassembly to Supplier and Supplier shall ask Customer to pay for the disassembly and returning.
   B. Supplier : Dispose the product and record/document such disposal



Article 2. Request for Disposal

1. If customer wants to dispose his/her ESS with supplier, customer shall inform such to supplier at least one month earlier. To request disposal of ESS, customer shall provide the following information to supplier:
   A. Installation or purchasing date of one's ESS product
   B. Product code and the number of disposing ESS
   C. Desired date of disposal
2. Supplier shall confirm disposal within 7 days after customer made disposal request to supplier. If disposal schedule needs to be adjusted, supplier can do so after getting customer's agreement. .
3. Customer issues PO for the disposal cost proposed by supplier.

Article 3. Return for Disposal

1. Once supplier confirms the date of disposal, customer shall disassemble installed ESS product for return beforehand.
2. Customer shall return his/her ESS to location designated earlier by supplier on the disposal date.
3. Supplier can prepare for ESS's return and delivery upon request from customer's PO.

Article 4. Complete Disposal

1. Supplier shall send a written notice to customer when disposal of the product is complete.

SAFETY DATA SHEET

1. Identification of the substance or mixture and of the supplier

A. GHS product identifier : MODEL CS100 (100Ah capacity)

B. Recommended use of the chemical and restrictions on use

Recommended use : Lithium-Ion battery

Restrictions on use : Use for recommended use only.

C. Supplier

Company name : SAMSUNG SDI Co., Ltd.

Address : 150-20, Gongse-ro, Giheung-gu, Yongin-si, Gyeonggi-do, Korea

Emergency phone number : +82-31-288-4415

Respondent : Cell development department

Fax : Not available

D. Further information

Battery-System: Lithium-Ion (Li-ion)

Voltage: 3.68V

Anode (negative electrode): based on intercalation graphite

Cathode (positive electrode): based on lithiated metal oxide (Cobalt, Nickel, Manganese)

Remark:

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SAMSUNG SDI Co., Ltd. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.

2. Hazards identification

※ This is a product that fulfills a certain function in solid state with specific shape without discharging any chemical substance in its use and has no obligation to write (M)SDS. Since this document contains the pre cautions for safe handling related to its materials or chemical substances consisting of this product, please note that these overall information is irrelevant to this product.

A. GHS classification of the substance/mixture

Not classified according to OSHA 29 CFR 1910.1200

B. GHS label elements, including precautionary statements

Pictogram and symbol :

Not applicable

Signal word :

Not applicable

Hazard statements :

Not applicable

Precautionary statements

Precaution :

Not applicable

Treatment :

Not applicable

Storage :

Not applicable

Disposal :

Not applicable

C. Other hazard information not included in hazard classification :

- Empirical data on effects on humans : If appropriately handled and if in accordance with the general hygienic rules, no damages to health have become known.
- There is no hazard when the measures for handling and storage are followed.
- In case of cell damage, possible release of dangerous substances and a flammable gas mixture.

3. Composition/information on ingredients

Chemical Name	Common Name(Synonyms)	CAS number	EC number	Content (%)
Cobalt lithium manganese nickel oxide	Not available	182442-95-1	695-690-9	23~30
1-methyl-2-pyrrolidone	1-methylpyrrolidin-2-one	872-50-4	212-828-1	15~23
Graphite	Grafito	7782-42-5	231-955-3	10~20
Aluminium	Al	7429-90-5	231-072-3	10~16
Copper	Cu	7440-50-8	231-159-6	2~10
Trade secret 1	Trade secret	Trade secret	Trade secret	1~10
Trade secret 2	Trade secret	Trade secret	Trade secret	1~10
Trade secret 3	Trade secret	Trade secret	Trade secret	1~5
Lithium Nickel Cobalt Aluminium oxide	LNCA	177997-13-6	700-042-6	1~3
Trade secret 4	Trade secret	Trade secret	Trade secret	1~3

Aluminium oxide	Activated Alumina	1344-28-1	215-691-6	1~3
Carbon black	Carbon	1333-86-4	215-609-9	0.1~0.99

4. First aid measures

※ General information

The following first aid measures are required only in case of exposure to interior battery components after damage of the external battery casing. Undamaged, closed cells do not represent a danger to the health.

A. Eye contact

- In case of contact with substance, immediately flush eyes with running water at least 20 minutes.

B. Skin contact

- In case of contact with substance, immediately flush skin with running water at least 20 minutes.
- Remove and isolate contaminated clothing and shoes.
- Wash contaminated clothing and shoes before reuse.
- Get immediate medical advice/attention.

C. Inhalation

- Specific medical treatment is urgent.
- Move victim to fresh air.
- Administer oxygen if breathing is difficult.

D. Ingestion

- Do not let him/her eat anything, if unconscious.
- Get immediate medical advice/attention.

E. Indication of immediate medical attention and notes for physician

- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

F. Most important symptoms and effects, both acute and delayed

Not available

5. Fire fighting measures

A. Suitable (and unsuitable) extinguishing media

- When the scale of the fire is small, use a HFC (hydrofluorocarbon) clean-agent fire extinguisher or alcohol resistant foam fire extinguishers. (In case of battery overheating, wear protective gear and immerse heated battery in water)
- In case of large fire, use large amount of water to extinguish.

B. Specific hazards arising from the chemical

- Flammable gas leaks before ignition and then the product ignites.

C. Special protective equipment and precautions for fire-fighters

- The ignited battery has a high temperature, so there is a risk of additional ignition even if the fire is extinguished at early stage. Sprinkle a large amount of water until the battery temperature drops to normal temperature.
- If the battery is ignited in multi-stacked condition, multi-stack should be disassembled and then extinguished so that heat is not transferred between batteries
- In the event of a battery fire, cool it by spraying water directly on the battery.
- When handling a overheated battery, wear heat-resistant protective equipment.

6. Accidental release measures

A. Personal precautions, protective equipment and emergency procedures

- Eliminate all ignition sources.
- Stop leak if you can do it without risk.
- Please note that materials and conditions to avoid.
- Ventilate the area.
- Do not touch or walk through spilled material.

B. Environmental precautions and protective procedures

- Prevent entry into waterways, sewers, basements or confined areas.

C. The methods of purification and removal

- With clean shovel place material into clean, dry container and cover loosely; move containers from spill area.

7. Handling and storage

A. Precautions for safe handling

- Avoid short circuiting the cell.
- Avoid mechanical damage of the cell.
- Do not open or disassemble.
- Please note that materials and conditions to avoid.
- Wash thoroughly after handling.
- Please work with reference to engineering controls and personal protective equipment.
- Be careful to high temperature.

B. Conditions for safe storage

- Storage at room temperature (approx. 20°C) at approx. 20% of the nominal capacity (OCV approx. 3.5 - 3.6 V).
- Store in a closed container.
- Store in cool and dry place.

8. Exposure controls/personal protection

A. Occupational Exposure limits

ACGIH regulation :

- Cobalt lithium manganese nickel oxide : TWA = 0.2 mg/m^3 (inhalable particulate matter, as Ni)(Nickel insoluble inorganic compounds), TWA = 0.1 mg/m^3 (inhalable particulate matter, as Ni)(Nickel soluble inorganic compounds), TWA = 0.02 mg/m^3 (as

Co)(Cobalt inorganic compounds), TWA = 0.02 mg/m^3 (respirable particulate matter, as Mn); 0.1 mg/m^3 (inhalable particulate matter, as Mn)(Manganese inorganic compounds)

- Graphite : TWA = 2 mg/m^3 (all forms except graphite fibers, respirable particulate matter)
- Aluminium : TWA = 1 mg/m^3 (respirable particulate matter)(Aluminum, Aluminum insoluble compounds)
- Copper : TWA = 0.2 mg/m^3 (Copper fume), TWA = 1 mg/m^3 (Copper dust and mist, Copper compounds as Cu)
- Lithium Nickel Cobalt Aluminium oxide : TWA = 0.2 mg/m^3 (inhalable particulate matter, as Ni)(Nickel insoluble inorganic compounds), TWA = 0.1 mg/m^3 (inhalable particulate matter, as Ni)(Nickel soluble inorganic compounds), TWA = 0.02 mg/m^3 (as Co)(Cobalt inorganic compounds), TWA = 1 mg/m^3 (respirable particulate matter)(Aluminum insoluble compounds)
- Aluminium oxide : TWA = 1 mg/m^3 (respirable particulate matter)(Aluminum, Aluminum insoluble compounds)
- Carbon black : TWA = 3 mg/m^3 (inhalable particulate matter)

OSHA regulation :

- Cobalt lithium manganese nickel oxide : TWA = 1 mg/m^3 (Nickel compounds), C = 5 mg/m^3 (Manganese compounds)
- Graphite : TWA = 15 mppcf
- Aluminium : TWA = 15 mg/m^3 (Aluminum metal (as Al), Total dust) ; 5 mg/m^3 (Respirable fraction)
- Copper : TWA = 0.1 mg/m^3 (Copper Fume (as Cu)) ; 1 mg/m^3 (Dusts and mists (as Cu), Cotton dust)
- Lithium Nickel Cobalt Aluminium oxide : TWA = 1 mg/m^3 (Nickel compounds)
- Aluminium oxide : TWA = 15 mg/m^3 (Total dust) ; 5 mg/m^3 (Respirable fraction)
- Carbon black : TWA = 3.5 mg/m^3

NIOSH regulation :

- Cobalt lithium manganese nickel oxide : TWA = 0.015 mg/m^3 (Nickel metal and other compounds, as Ni), TWA = 1 mg/m^3, STEL = 3 mg/m^3 (Manganese compounds)
- Graphite : TWA = 2.5 mg/m^3 (resp)
- Aluminium TWA = 10 mg/m^3 (total) ; 5 mg/m^3 (resp)
- Copper : TWA = 1 mg/m^3 (Copper (dusts and mists, as Cu), other copper compounds (as Cu) except Copper fume)
- Lithium Nickel Cobalt Aluminium oxide : TWA = 0.015 mg/m^3 (Nickel metal and other compounds, as Ni)
- Carbon black : TWA = 3.5 mg/m^3

Biological exposure index : Not available

B. Appropriate engineering controls

- Provide local exhaust ventilation system or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.

C. Personal protective equipment

Respiratory protection :
- Wear NIOSH or European Standard EN 149 approved full or half face piece (with goggles) respiratory protective equipment when necessary.
- In case exposed to particulate material, the respiratory protective equipments as follow are recommended.
;facepiece filtering respirator or air-purifying respirator, high-efficiency particulate air(HEPA) filter media or respirator equipped with powered fan, filter media of use(dust, mist, fume)
- In lack of oxygen(< 19.5%), wear the supplied-air respirator or self-contained oxygen breathing apparatus.

Eye protection :
- Wear facepiece with goggles to protect.
- An eye wash unit and safety shower station should be available nearby work place.
- Wear breathable safety goggles to protect from particulate material causing eye irritation or other disorder.
- An eye wash unit and safety shower station should be available nearby work place.

Hand protection :
- Wear chemical resistant gloves.
- Wear appropriate protective gloves by considering physical and chemical properties of chemicals.

Body protection :
- Wear appropriate protective chemical resistant clothing.
- Wear appropriate protective clothing by considering physical and chemical properties of chemicals.

9. Physical and chemical properties

A. Appearance
Description : Solid
Color : Various
B. Odor : Odorless
C. Odor threshold : Not available
D. pH : Not available
E. Melting point/freezing point : Not available
F. Initial boiling point and boiling range : Not available
G. Flash point : Not available
H. Evaporation rate : Not available
I. Flammability (solid, gas) : Not available
J. Upper/lower flammability or explosive limits : Not available
K. Vapor pressure : Not available
L. Solubility (ies) : Insoluble
M. Vapor density : Not available
N. Specific gravity : Not available
O. Partition coefficient: n-octanol/water : Not available
P. Auto ignition temperature : Not available

Q. Decomposition temperature : Not available
R. Viscosity : Not available
S. Molecular weight : Not available

10. Stability and reactivity

A. Chemical stability and Possibility of hazardous reactions

- Stable in general.
- In case of open cells, there is the possibility of hydrofluoric acid and carbon monoxide release.
- Fire may produce irritating and/or toxic gases.
- Inhalation of material may be harmful.

B. Conditions to avoid

- Ignition sources (heat, sparks or flames)

C. Incompatible materials

- Combustibles

D. Hazardous decomposition products

- No decomposition if stored and applied as directed.
- Irritating and/or toxic gases

11. Toxicological information

※ This is a product that fulfills a certain function in solid state with specific shape without discharging any chemical substance in its use and has no obligation to write (M)SDS. Since this document contains the pre cautions for safe handling related to its materials or chemical substances consisting of this product, please note that these overall information is irrelevant to this product.

A. Information on the likely routes of exposure

Not available

B. Information of Health Hazardous

Acute toxicity

Oral : Not classified (ATEmix = 1684 mg/kg)

- Cobalt lithium manganese nickel oxide : Rat LD_{50} > 2000 mg/kg(NCIS)
- 1-methyl-2-pyrrolidone : Rat LD_{50} = 4150 mg/kg(OECD Guideline 401)
- Graphite : Rat LD_{50} > 2000 mg/kg(OECD Guideline 423, GLP)
- Aluminium : Rat LD_{50} > 15900 mg/kg(Read-across)(OECD Guideline 401)
- Copper : Rat LD_{50} = 481 mg/kg(OECD Guideline 401, GLP)
- Trade secret 1 : Rat LD_{50} = 10,400 mg/kg(OECD Guideline 401)
- Trade secret 2 : Rat LD_{50} > 5,000 mg/kg(OECD Guideline 401, GLP)
- Trade secret 3 : Rat LD_{50} > 5,000 mg/kg(male/female)(OECD Guideline 401, GLP)
- Lithium Nickel Cobalt Aluminium oxide : Rat LD_{50} > 2000 mg/kg(OECD Guideline 420, GLP)
- Trade secret 4 : Rat LD_{50} = 50~300 mg/kg(OECD Guideline 423, GLP)
- Aluminium oxide : Rat LD_{50} > 10000 mg/kg(OECD Guideline 401, GLP)
- Carbon black : Rat LD_{50} > 10000 mg/kg(OECD Guideline 401, GLP)

Dermal : Not classified (ATEmix = 13200 mg/kg)

- 1-methyl-2-pyrrolidone : Rat LD_{50} > 5,000 mg/kg(OECD Guideline 402)
- Copper : Rat LD_{50} > 2000 mg/kg(OECD Guideline 402, GLP)
- Trade secret 1 : Rat LD_{50} = 2,000 mg/kg(male/female)(OECD Guideline 402, GLP)
- Trade secret 3 : Rabbit LD_{50} > 2,000 mg/kg(male/female)(GLP)

Inhalation : Not classified (ATEmix > 0.888 mg/L / 4 hr)

- 1-methyl-2-pyrrolidone : Rat LC_{50} > 5.1 mg/L / 4 hr(OECD Guideline 403)
- Graphite : Rat LC_{50} > 2000 mg/m³ / 4 hr(OECD Guideline 403, GLP)
- Aluminium : Rat LC_{50} > 0.888 mg/L / 4 hr(OECD Guideline 403)
- Copper : Rat LC_{50} > 5.11 mg/L / 4 hr(OECD Guideline 436, GLP)
- Trade secret 1 : Rat LC_0 = 730 mg/m³ / 8 hr(male/female)(OECD Guideline 403)
- Trade secret 2 : Rat LC_{50} > 17.6 mg/L / 4 hr(OECD Guideline 403, GLP)
- Trade secret 3 : Rat LC_{50} > 5.36 mg/L / 4 hr(male/female)(OECD Guideline 403, GLP)
- Aluminium oxide : Rat LC_{50} > 2.3 mg/L / 4 hr(OECD Guideline 403, GLP)
- Carbon black : Rat LC_0 = 4.6 mg/m³ / 4 hr(OECD Guideline 403)

Skin corrosion/ irritation : Not classified

- Cobalt lithium manganese nickel oxide : the test material was not irritating.
- 1-methyl-2-pyrrolidone : In the skin irritation test using rabbits, the test material was not irritating. (OECD Guideline 404)
- Graphite : In the skin irritation test with rabbits, the test material was not irritating. (OECD Guideline 404, GLP)
- Aluminium : In the skin irritation test using rabbits, the test material was not irritating. (Read-across)(OECD Guideline 404)
- Copper : In the skin irritation test using rabbits, the test material was not irritating. (OECD Guideline 404, GLP)
- Trade secret 1 : In the skin irritation test using rabbits, the test material was not classified. (OECD Guideline 404, GLP)
- Trade secret 2 : In the skin irritation test using rabbits, the test material was not irritating. (OECD Guideline 404, GLP)
- Trade secret 3 : In the skin irritation test using rabbits, the test material was not irritating. (OECD Guideline 404)
- Lithium Nickel Cobalt Aluminium oxide : In the skin irritation test using rabbits, the test material was corrosive. (an exposure period of 1-hour)(OECD Guideline 404, GLP)
- Trade secret 4 : In the skin irritation test using human skin model, the test material was corrosive. (EU Method B.40, GLP)
- Aluminium oxide : In the skin irritation test using rabbits, very slight erythema was observed. it would not lead to classification.(2/12)(OECD Guideline 404)
- Carbon black : In the skin irritation test using rabbits, the test material was not classified. (OECD Guideline 404)

Serious eye damage/ irritation : Not classified

- Cobalt lithium manganese nickel oxide : the test material was not irritating.
- 1-methyl-2-pyrrolidone : In the eye irritation test using rabbits, the test material was irritating. Moderate ocular effects observed, but Corneal and conjunctival effects were reversible within 14 days and 21 days, respectively. (OECD Guideline 405)
- Graphite : In the eyes irritation test with rabbits, the test material was slightly irritating. it was fully reversible within 7 days. (OECD Guideline 405, GLP)

- Aluminium : In the eye irritation test using rabbits, the test material was not irritating. (Read-across)
- Copper : In the eyes irritation test with rabbits, the test material was irritating. but it was fully reversible within 7 days. (OECD Guideline 405, GLP)
- Trade secret 1 : In the eye irritation test using rabbits, the test material was mildly irritating. (OECD Guideline 405, GLP)
- Trade secret 2 : In the eye irritation test using rabbits, the test material was not irritating. (OECD Guideline 405, GLP)
- Trade secret 3 : In the eye irritation test using rabbits, the test material was not irritating. (GLP)
- Lithium Nickel Cobalt Aluminium oxide : In the eye irritation test using The SkinEthic RHC model consists of transformed human keratinocytes, the test material was Iirritating.
- Trade secret 4 : In the eye irritation test using fertilised brown leghorn chicken eggs, the test material was severely irritating. (GLP)
- Aluminium oxide : In the eyes irritation test using rabbits, slight erythema was observed. it would not lead to classification.(OECD Guideline 405)
- Carbon black : In the eye irritation test using rabbits, the test material was not irritating. (OECD Guideline 405)

Respiratory sensitization : Not classified

- Aluminium : In the respiratory sensitization test using mice, the test material was not respiratory sensitization. (Read-across)
- Aluminium oxide : In the respiratory sensitization test using rats, this material was not respiratory sensitizing.(Effects of Asian Sand Dust, Arizona Sand Dust, Amorphous Silica and Aluminium Oxide on Allergic Inflammation in the Murine Lung, 2008)
- Carbon black : This material has not been tested in animals for sensitisation effects on the respiratory tract. In humans, no cases of allergies were reported to the responsible occupational physicians.

Skin sensitization : Not classified

- Cobalt lithium manganese nickel oxide : this material was not skin sensitizing. (Mouse)
- 1-methyl-2-pyrrolidone : In the skin sensitization test using mice, the test material was not skin sensitizing. (OECD Guideline 429, GLP)
- Graphite : In the skin sensitization test using mice, the test material was not skin sensitizing. (OECD Guideline 429, GLP)
- Aluminium : In the skin sensitization test using guinea pigs, the test material was not skin sensitizing.
- Copper : In the skin sensitization test using guinea pigs, the test material was not skin sensitizing. (OECD Guideline 406, GLP)
- Trade secret 1 : In the skin sensitization test using guinea pigs, the test material was not classified. (OECD Guideline 406, GLP)
- Trade secret 2 : In the skin sensitization test using guinea pigs, the test material was not skin sensitizing. (OECD Guideline 406, GLP)
- Trade secret 3 : In the skin sensitization test using guinea pigs, the test material was not skin sensitizing. (OECD Guideline 406, GLP)

- Lithium Nickel Cobalt Aluminium oxide : In the skin sensitization test using mouse, the test material was not skin sensitizing. (OECD Guideline 429, GLP)
- Trade secret 4 : In the skin sensitization test using mice, the test material was not skin sensitizing. (OECD Guideline 429, GLP)
- Aluminium oxide : In the skin sensitization test using guinea pigs, this material was not skin sensitizing.(Landsteiner / Draize method)
- Carbon black : In the skin sensitization test using guinea pigs, the test material was not skin sensitizing. (OECD Guideline 406, GLP)

Carcinogenicity : Not classified

- Cobalt lithium manganese nickel oxide :
  - IARC :
    - Group 1 (Nickel compounds)
    - Group 2B (Cobalt and cobalt compounds)
  - ACGIH:
    - A1 (Nickel insoluble inorganic compounds),
    - A3 (Cobalt inorganic compounds)
    - A4 (Nickel soluble inorganic compounds, Manganese inorganic compounds)
  - NTP:
    - K (Nickel compounds)
    - R (Cobalt compounds)
  - OSHA:
    - Present (Nickel compounds, Cobalt compounds)
- Aluminium :
  - ACGIH: A4 (Aluminum, Aluminum insoluble compounds)
- Lithium Nickel Cobalt Aluminium oxide :
  - IARC :
    - Group 1 (Nickel compounds)
    - Group 2B (Cobalt and cobalt compounds)
  - ACGIH:
    - A1 (Nickel insoluble inorganic compounds),
    - A3 (Cobalt inorganic compounds)
    - A4 (Nickel soluble inorganic compounds, Aluminum insoluble compounds)
  - NTP:
    - K (Nickel compounds)
    - R (Cobalt compounds)
  - OSHA:
    - Present (Nickel compounds, Cobalt compounds)
- Carbon black :
  - IARC : Group 2B
  - ACGIH: A3
  - OSHA: Present

Mutagenicity : Not classified

- Cobalt lithium manganese nickel oxide : Nagative : in vitro test ((Ames test, S. typhimurium, E. Coli)(Chromosome aberration test, human lymphocyte)
- 1-methyl-2-pyrrolidone : Negative reactions were observed in in vitro tests(Bacterial Reverse Mutation Assay(OECD Guideline 471), Mammalian Gene

Mutation Test(OECD Guideline 476, GLP) and DNA Damage and/or Repair Study(OECD Guideline 482, GLP)).
Negative reactions were observed in in vivo tests(Mammalian Erythrocyte Micronucleus Test(OECD Guideline 474, GLP) and Mammalian Bone Marrow chromosome Aberration Test(OECD Guideline 475, GLP)).
- Graphite : Negative reactions were observed in in vitro test(Bacterial Reverse Mutation Assay(OECD Guideline 471, GLP)).
- Aluminium : Negative reactions were observed in both in vivo (Mammalian Erythrocyte Micronucleus Test(OECD Guideline 474, GLP)) and in vitro (Mammalian cell gene mutation test(OECD Guideline 476, GLP)).
- Copper : Negative reactions were observed in in vivo test(mammalian somatic cell study: cytogenicity/erythrocyte micronucleus(EU Method B.12, GLP)).
- Trade secret 1 : Negative reactions were observed in vitro (Bacterial Reverse Mutation Assay(OECD Guideline 471, GLP)).
- Trade secret 2 : Negative reactions were observed in vitro (Mammalian Chromosome Aberration Test (OECD Guideline 473, GLP))
- Trade secret 3 : Negative reactions were observed in in vivo (Mammalian Spermatogonial Chromosome Aberration Test (OECD Guideline 483, GLP))
- Lithium Nickel Cobalt Aluminium oxide : Negative reactions were observed in in vitro test(Bacterial Reverse Mutation Assay(OECD Guideline 471, GLP))
- Trade secret 4 : Negative reactions were observed in both in vivo (Mammalian Erythrocyte Micronucleus Test(OECD Guideline 474)) and in vitro (Bacterial Reverse Mutation Assay(OECD Guideline 471, GLP)).
- Aluminium oxide : In in vivo test (Mammalian Bone Marrow Chromosome Aberration Test (OECD Guideline 475)), a positive reation was observed.
- Carbon black : Positive reactions were observed in both in vitro (Chromosomal aberrations test (OECD Guideline 476, GLP)) and in vivo (ypoxanthine-guanine phosphoribosyl transferase gene (hprt) mutations in alveolar epithelial cells).

Reproductive toxicity : Not classified

- 1-methyl-2-pyrrolidone : In the two-generation reproductive toxicity test with rats, developmental toxicity was evidenced by increased pup mortality and reduced body weight gain, including corresponding effects in the investigated organs, in pups treated at 500/350 mg/kg bw/day. (NOAEL(F) = 160 mg/kg bw/day) (OECD Guideline 416, GLP)
- Graphite : In the reproductive toxicity with rats, there were no significant adverse effects on reproductive parameters. (OECD Guideline 422, GLP)
- Aluminium : In the reproductive toxicity and developmental toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 422, GLP)(OECD Guideline 414)
- Copper : In the reproductive toxicity and developmental toxicity test with rats, there were no significant adverse effects on reproductive parameters and no evidence of malformations at any doses. (OECD Guideline 416, 414, GLP)
- Trade secret 1 : In the reproductive toxicity test using mouse, adverse effects were not observed, respectively. (GLP)
In the developmental toxicity test using rabbits, adverse effects were not observed, respectively. (GLP)

- Trade secret 2 : In the reproductive toxicity and developmental toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 414)
- Trade secret 3 : In the reproductive toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 415, GLP)
In the developmental toxicity test using rabbits, adverse effects were not observed, respectively. (OECD Guideline 414, GLP)
- Lithium Nickel Cobalt Aluminium oxide : In the reproductive toxicity and developmental toxicity test with rats, as the 500 mg/kg/day treatment group was terminated early due to excessive dose level no definitive reproductive effect could be established. and no effect of treatment was detected on reproduction or offspring development, at a treatment level up to 150 mg/kg/day. (OECD Guideline 422, GLP)
- Trade secret 4 : In the reproductive toxicity and developmental toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 416, GLP)(OECD Guideline 414)
- Aluminium oxide : In the reproductive toxicity test using rats, no toxicologically significant effects were noted. (OECD Guideline 422, GLP)(Read across: Al(OH)13Cl17(in aqueous solution))
- Carbon black : In the reproductive toxicity and developmental toxicity test using mice, adverse effects were not observed, respectively. (OECD Guideline 414, GLP)

Specific target organ toxicity (single exposure) : Not classified

- 1-methyl-2-pyrrolidone : In the acute oral toxicity test with rats, ataxia and diuresis(4,150 mg/kg bw) were observed. (OECD Guideline 401)
- Graphite : In the acute oral toxicity test with rats, no signs of discomfort or toxicity effects. (OECD Guideline 423, GLP)
- Aluminium : In the acute oral toxicity test using rats, adverse effects were not observed, respectively. (Read-across)(OECD Guideline 401) In the acute inhalation toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 403)
- Copper : In the acute oral toxicity test with rats, clinical signs observed included lethargy, prostrate posture, green coloured diarrhoea, voiding few faeces and moribundity. (OECD Guideline 401, GLP) In the acute inhalation toxicity test with rats, slight to moderate ataxia, slight to moderate tremor and slight to moderate dyspnoea were observed. (OECD Guideline 436, GLP)
- Trade secret 1 : In the acute dermal/inhalation toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 402, GLP)(OECD Guideline 403)
- Trade secret 2 : In the acute oral and inhalation toxicity test using rats, ataxia, hunched posture, lethargy, decreased respiratory rate and laboured respiration are observed. (OECD Guideline 401, GLP) (OECD Guideline 403, GLP)
- Trade secret 3 : In the acute oral toxicity test using rats, hypoactivity, ataxia and loss of the righting reflex were observed. (OECD Guideline 401, GLP)
In the acute dermal toxicity test using rabbits, adverse effects were not observed, respectively. (GLP)
In the acute inhalation toxicity test using rats, adverse effects were not observed, respectively. (OECD Guideline 403, GLP)

- Lithium Nickel Cobalt Aluminium oxide : In the repeated oral toxicity test with rats, no signs of systemic tocicity were noted during the observation period. (OECD Guideline 420, GLP)
- Trade secret 4 : In the acute oral toxcity test with rats, lethargy, hunched posture, uncoordinated movements, piloerection were observed. (OECD Guideline 423, GLP)
- Aluminium oxide : In the acute oral/inhalation toxicity test using rats, no abnormal clinical signs were recorded.(OECD Guideline 401/403, GLP)
- Carbon black : In the acute oral toxicity and acute inhalation toxicity test with rats, adverse effects were not observed, respectively. (OECD Guideline 401, GLP)(OECD Guideline 403)

Specific target organ toxicity (repeat exposure) : Not classified

- Cobalt lithium manganese nickel oxide : In surviving animals in 50 mg / ㎥ (3 weeks recovery group), the minimum degradation / regeneration in lung was observed. NAOEC (no adverse effect observation) was not decided.(Rat, 6 hr/day, 2 times exposure, 28 days observation, 2, 10, 50mg / m3, inhalation test, short term - lung toxicity test)
- 1-methyl-2-pyrrolidone : In the repeated oral toxicity test in 90 days with rats, a specific target organ for compound-related adverse systemic toxicity was not identified. (OECD Guideline 408, GLP)
- Graphite : In the repeated oral toxicity test with rats, no signs of discomfort or toxicity effects. (OECD Guideline 422, GLP) In the repeated inhalation toxicity test with rats, in the Graphite high-dose group, clearly adverse effects such as markedly increased incidence of interstitial fibrosis, were seen in the lung. (OECD Guideline 412, GLP)
- Aluminium : "In the repeated oral toxicity toxicity tests using rats, toxicity to organs was not observed. (Read-across)(OECD Guideline 422, GLP) In the repeated inhalation toxicity toxicity tests using rats, toxicity to organs was not observed. (OECD Guideline 413)"
- Copper : In the repeated oral toxicity and inhalation toxicity test using rats, toxicity to organs was not observed. (EU Method B.26, GLP)(OECD Guideline 412, GLP)
- Trade secret 1 : In the repeated oral toxicity tests using rats, toxicity to organs was not observed. (OECD Guideline 452)
- Trade secret 2 : In the repeated oral toxicity test using rats, toxicity to organs was not observed. OECD Guideline 407, GLP)
- Trade secret 3 : In the repeated oral toxicity tests using rats, toxicity to organs was not observed. (OECD Guideline 408, GLP)
- Lithium Nickel Cobalt Aluminium oxide : In the repeated oral toxicity test with rats, microscopic changes in the spleen and kidneys seen for animals of either sex at 500 and 150 mg/kg/day and males only at 50 mg/kg/day. The changes identified in the kidneys of male rats are specific for male rats only and are considered not to represent “serious damage” to health. (OECD Guideline 422, GLP)
- Aluminium oxide : In the repeated oral toxicity test using rats, no toxicologically significant effects were noted. (OECD Guideline 422, GLP)(Read across: Aluminium chloride basic)

In the repeated inhalation toxicity test using rats, Intratracheal injection of aluminium powder caused nodular pulmonary fibrosis in the lungs of the rats only at the highest dose administered (100 mg). but Progressive fibrosis was not observed in rats on inhalation exposure to the powders indicating that the intratracheal instillation mode of test compound delivery may lead to artifacts not representative of actual inhalation exposures. (OECD Guideline 413)

- Carbon black : In the sub-chronic inhalation toxicity test using rats, there was clear evidence of inflammation and some alveolar epithelial cell hyperplasia and fibrosis at the high exposure group. In the mid-exposure group there was evidence of inflammation characterised by accumulation of neutrophils and macrophages within the alveolar spaces.

Aspiration Hazard : Not available

12. Ecological information

※ This is a product that fulfills a certain function in solid state with specific shape without discharging any chemical substance in its use and has no obligation to write (M)SDS. Since this document contains the pre cautions for safe handling related to its materials or chemical substances consisting of this product, please note that these overall information is irrelevant to this product.

A. Ecological toxicity

- Acute toxicity : Not classified (L(E)C_{50} = 0.33 mg/L)

Fish :

- 1-methyl-2-pyrrolidone : 96hr-LC_{50}(*Oncorhynchus mykiss*) > 500 mg/L (OBBA-bulletin No. 33, 1975)
- Graphite : 96hr-LC_{50}(*Danio rerio*) > 100 mg/L (OECD Guideline 203, GLP)
- Aluminium : 96hr-LC_{50}(*Pimephales promelas*) = 1.16 mg/L (GLP)
- Copper : 96hr-LC_{50}(*Oncorhynchus mykiss*) = 0.164 mg/L
- Trade secret 1 : 96hr-LC_{50}(*Oncorhynchus mykiss*) > 100 mg/L (OECD Guideline 203, GLP)
- Trade secret 2 : 96hr-LC_{50}(*Oncorhynchus mykiss*) > 100 mg/L (OECD Guideline 203, GLP)
- Trade secret 3 : 96hr-LC_{50}((*Danio rerio*) ≥ 100 mg/L (OECD Guideline 203, GLP)
- Trade secret 4 : 96hr-LC_{50}(*Oncorhynchus mykiss*) = 51 mg/L
- Aluminium oxide : 96hr-LC_{50}(*Pimephales promelas*) = 1.16 mg/L (Read across : aluminum chloride hexahydrate)(PA/600/4-85/013, GLP)
- Carbon black : 96hr-LC0(*Danio rerio*) = 1000 mg/L (OECD Guideline 203, GLP)

crustacean :

- 1-methyl-2-pyrrolidone : 24hr-EC_{50}(*Daphnia magna*) > 1000 mg/L (DIN 38412 Part 11)
- Graphite : 48hr-EC_{50}(*Daphnia magna*) > 100 mg/L (OECD Guideline 202, GLP)
- Aluminium : 48hr-LC_{50}(*Ceriodaphnia dubia*) = 0.72 mg/L (GLP)
- Copper : 48hr-LC_{50}(*Ceriodaphnia dubia*) = 0.014 mg/L
- Trade secret 1 : 48hr-EC_{50}(*Ceriodaphnia dubia*) = 5,900 mg/L
- Trade secret 2 : 48hr-EC_{50}(*Daphnia magna*) > 100 mg/L (OECD Guideline 202, GLP)
- Trade secret 3 : 48hr-EC_{50}(*Daphnia magna*) > 100 mg/L (OECD Guideline 202, GLP)
- Trade secret 4 : 48hr-LC_{50}(*Daphnia magna*) > 100 mg/L (OECD Guideline 202, GLP)
- Aluminium oxide : 48hr-LC_{50}(*Ceriodaphnia dubia*) = 0.72 mg/L (Read across : aluminum chloride hexahydrate)(EPA/600/4-85/013, GLP)
- Carbon black : 24hr-EC_{50}(*Daphnia magna*) > 5600 mg/L (OECD Guideline 202, GLP)

Algae :

- 1-methyl-2-pyrrolidone : 72hr-EC_{50}(*Desmodesmus subspicatus*) = 600.5 mg/L (DIN 38412 Part9)
- Graphite : 72hr-EC_{50}(*Pseudokirchneriella subcapitata*) > 100 mg/L (OECD Guideline 201, GLP)
- Aluminium : 72hr-EC_{50}(*Pseudokirchneriella subcapitata*) = 0.2 mg/L (OECD Guideline 201, GLP)
- Copper : 96hr-EC_{50}(*Chlamydomonas reinhardtii*) = 0.047 mg/L
- Trade secret 1 : 72hr-EC_{50}(*Pseudokirchneriella subcapitata*) > 100 mg/L (OECD Guideline 201,GLP)
- Trade secret 2 : 72hr-EC_{50}(*Desmodesmus subspicatus*) > 62 mg/L (OECD Guideline 201, GLP)
- Trade secret 3 : 72hr-EC_{50}(*Pseudokirchneriella subcapitata*) > 100 mg/L (OECD Guideline 201, GLP)
- Trade secret 4 : 96hr-EC_{50}(*Pseudokirchneriella subcapitata*) > 100 mg/L (OECD Guideline 201, GLP)
- Aluminium oxide : 72hr-EC_{50}(*Selenastrum capricornutum*) = 1.05 mg/L (Read across : Aluminium powder)(OECD Guideline 201, GLP)
- Carbon black : 72hr-EC_{50}(*Desmodesmus subspicatus*) > 10000 mg/L (OECD Guideline 201, GLP)

- Chronic toxicity : Not classified

Fish :

- Aluminium : 33day-NOEC(*Danio rerio*) = 0.0715 mg/L (OECD Guideline 210, GLP)
- Copper : 30day-NOEC(*Perca fluviatilis*) = 0.188 mg/L (OECD Guideline 204)
- Trade secret 4 : 22day-NOEC(*Pimephales promelas*) = 0.2 mg/L (EPA 540/86, GLP)
- Aluminium oxide : 33day-NOEC(*Brachydanio rerio*) = 0.0715 mg/L (OECD Guideline 210, GLP)(Read across : reagent grade aluminum nitrate nonahydrate)

crustacean :

- 1-methyl-2-pyrrolidone : 21day-NOEC = 12.5 mg/L (OECD Guideline 211, GLP)
- Aluminium : 28day-NOEC(*Hyalella azteca*) = 0.0531 mg/L (GLP)
- Copper : 14day-NOEC(*Penaeus mergulensis and Penaeus monodon (prawns*) = 0.033 mg/L
- Trade secret 3 : 21day-NOEC(*Daphnia magna*) = 25 mg/L (OECD Guideline 211, GLP)
- Trade secret 4 : 7day-NOEC(*Ceriodaphnia dubia*) = 2.55 mg/L (EPA/600/4-91/002)
- Aluminium oxide : 17day-NOEC(*Aeolosoma sp.*) = 0.9625 mg/L (GLP)(Read across: Aluminum nitrate nonahydrate)

Algae :

- 1-methyl-2-pyrrolidone : 72hr-EC_{50}(*Desmodesmus subspicatus*) = 672.8 mg/L (DIN 38412 Part9)
- Graphite : 72hr-NOEC(*Pseudokirchneriella subcapitata*) ≥ 100 mg/L (OECD Guideline 201, GLP)
- Copper : 19day-NOEC(*Macrocystis pyrifera*) = 0.0102 mg/L
- Trade secret 1 : 72hr-NOEC(*Pseudokirchneriella subcapitata*) = 100 mg/L (OECD Guideline 201,GLP)
- Trade secret 2 : 72hr-NOEC(*Desmodesmus subspicatus*) = 62 mg/L (OECD Guideline 201, GLP)

- Trade secret 4 : 96hr-NOEC(*Pseudokirchneriella subcapitata*) = 22 mg/L (OECD Guideline 201, GLP)
- Aluminium oxide : 72hr-NOEC(*Selenastrum capricornutum*) = 0.28 mg/L (Read across : Aluminium powder)(OECD Guideline 201, GLP)
- Carbon black : 72hr-NOEC(*Desmodesmus subspicatus*) > 10000 mg/L (OECD Guideline 201, GLP)

B. Persistence and degradability

Persistence :

- 1-methyl-2-pyrrolidone : Low persistency (log K_{ow} is less than 4 estimated.) (log K_{ow} = -0.46)
- Trade secret 1 : Low persistency (log K_{ow} is less than 4 estimated.) (log K_{ow} = 0.11) (20 °C, 5.33 < pH < 5.79)
- Trade secret 2 : Low persistency (log K_{ow} is less than 4 estimated.) (log K_{ow} = 0.972) (40 °C, EU Method A.8, GLP)
- Trade secret 3 : Low persistency (log K_{ow} is less than 4 estimated.) (log K_{ow} = 0.354) (20°C, 6.5 < pH < 7.5)
- Trade secret 4 : Hydrolysis readily in contact with water. According to this it was not possible to determine the partition coefficient. (OECD Guideline 107, GLP)

Degradability :

- Cobalt lithium manganese nickel oxide : Because it is an inorganic substance, it is not decomposed.

C. Bioaccumulative potential

Bioaccumulation :

- 1-methyl-2-pyrrolidone : Bioaccumulation is expected to be low according to the BCF < 500 (BCF = 3.162) (estimated)
- Trade secret 3 : Bioaccumulation is expected to be low according to the BCF < 500 (BCF < 3.2)
- Trade secret 4 : Bioaccumulation is expected to be low according to the BCF < 500 (BCF = 53~58)

Biodegradation :

- 1-methyl-2-pyrrolidone : As well-biodegraded, it is expected to have low accumulation potential in living organisms(73% biodegradation was observed after 28 days) (OECD Guideline 301C)
- Trade secret 1 : As well-biodegraded, it is expected to have low accumulation potential in living organisms(86% biodegradation was observed after 29 days) (OECD Guideline 301B)
- Trade secret 2 : As well-biodegraded, it is expected to have low accumulation potential in living organisms(98% biodegradation was observed after 28 days) (GLP)
- Trade secret 3 : As well-biodegraded, it is expected to have low accumulation potential in living organisms(86% biodegradation was observed after 28 days) (OECD Guideline 301C)

D. Mobility in soil :

- 1-methyl-2-pyrrolidone : No potency of mobility to soil. (K_{oc} = 4.65) (estimated)
- Trade secret 1 : No potency of mobility to soil. (K_{oc} = 11.9)
- Trade secret 2 : No potency of mobility to soil. (K_{oc} = 1.58) (OECD Guideline 121, GLP)

- Trade secret 3 : No potency of mobility to soil. (K_{oc} = 2.9 ~ 6.65) (25 °C)

E. Other hazardous effect : Not available

F. Hazardous to the ozone layer : Not applicable

13. Disposal considerations

A. Disposal method :

- Waste must be disposed of in accordance with federal, state and local environmental control regulations.

B. Disposal precaution :

- Consider the required attentions in accordance with waste treatment management regulation.

14. Transport information

※ If those lithium-ion batteries are packed with or contained in an equipment, then it is the responsibility o f the shipper to ensure that the consignment are packed in compliance to the latest edition of the IATA Dan gerous Goods Regulations section II of either Packing Instruction 966 or 967 in order for that consignment to be declared as NOT RESTRICTED (non-hazardous/non-Dangerous). If those lithium-ion batteries are p acked with or contained in an equipment, UN No. is UN3481.

A. UN Number : 3480

B. UN Proper shipping name : LITHIUM ION BATTERIES (including lithium ion polymer batteries)

C. Transport Hazard class : 9

D. Packing group : II

E. Special provisions : 188

F. Packing instructions : P903

G. Environmental hazards : No

H. Special precautions

in case of fire : F-A

in case of leakage : S-I

I. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not Available

J. IATA Transport : PI 965-Section IB

K. Package labels :

15. Regulatory information

A. U.S.A management information (OSHA Regulation) :

U.S.A Inventory (TSCA)

- Cobalt lithium manganese nickel oxide : Present [PMN; S; 5E] (ACTIVE)
- 1-methyl-2-pyrrolidone : Present [R] (ACTIVE)
- Graphite : Present (ACTIVE)
- Aluminium : Present (ACTIVE)
- Copper : Present (ACTIVE)
- Trade secret 1 : Present (ACTIVE)
- Trade secret 2 : Present (ACTIVE)
- Trade secret 3 : Present (ACTIVE)
- Lithium Nickel Cobalt Aluminium oxide : Present [PMN] (ACTIVE)
- Trade secret 4 : Present [PMN] (ACTIVE)
- Aluminium oxide : Present (ACTIVE)
- Carbon black : Present (ACTIVE)

U.S.A management information (CERCLA Regulation) :

- Copper : 5000lb

U.S.A management information (EPCRA 302 Regulation) : Not regulated

U.S.A management information (EPCRA 304 Regulation) : Not regulated

U.S.A management information (EPCRA 313 Regulation) :

- Cobalt lithium manganese nickel oxide : Regulated (Nickel, Cobalt, Manganese compounds)
- 1-methyl-2-pyrrolidone : Regulated
- Aluminium : Regulated (fume or dust)
- Copper : Regulated
- Lithium Nickel Cobalt Aluminium oxide : Regulated (Nickel Compounds, Cobalt Compounds)
- Aluminium oxide : Regulated (fibrous forms)

Substance of Rotterdam Convention : Not regulated

Substance of Stockholm Convention : Not regulated

Substance of Montreal Protocol : Not regulated

16. Other information

A. Information source and references :

UN Recommendations on the transport of dangerous goods 17th
Emergency Response Guidebook 2008;
http://phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/erg2008_eng.pdf
EU CLP; https://echa.europa.eu/information-on-chemicals/cl-inventory-database
REACH information on registered substances; https://echa.europa.eu/information-on-chemicals/registered-substances
U.S. National library of Medicine (NLM) Hazardous Substances Data Bank(HSDB);
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
OECD SIDS; http://webnet.oecd.org/hpv/ui/Search.aspx
ECOTOX; http://cfpub.epa.gov/ecotox/
EPISUITE v4.11; https://www.epa.gov/tsca-screening-tools/download-epi-suitetm-estimation-program-interface-v411
Chemicalbook; http://www.chemicalbook.com/ProductIndex_EN.aspx

LookChem; http://www.lookchem.com/
Chemblink;http://www.chemblink.com/
SIGMA-ALDRICH; http://www.sigmaaldrich.com/united-states.html
Chemspider; http://www.chemspider.com/
IARC Monographs on the Evaluation of Carcinogenic Risks to Humans; http://monographs.iarc.fr
National Toxicology Program; http://ntp.niehs.nih.gov/results/dbsearch/
TOMES-LOLI®; http://www.rightanswerknowledge.com/loginRA.asp
American Conference of Governmental Industrial Hygienists TLVs and BEIs.
NIOSH Pocket Guide; http://www.cdc.gov/niosh/npg/npgdcas.html

B. Issuing date : 12. JUNE, 2019

C. Revision number and date

revision number : Rev.(00)

date of the latest revision : 12. JUNE, 2019

D. Others :

• The content is based on the latest information and knowledge that we currently possess.

• This SDS was authored to aid buyer, processor or any other third person who handles the chemical of subject in the SDS; additionally, it does not warrant suitability of the chemical for special purposes or the commercial use of statements that approves the use of it in combination with other chemicals as well as technical or legal liabilities.

• The content of the SDS may vary depending on the country or the region and may not coincide with the actual regulations. Therefore, the buyer or the processor of the chemical is responsible for observing responsible government's or the region's regulations.

Appendix E

Health and Safety Concerns of Photovoltaic Solar Panels

NC State University – NC Clean Energy Technology Center (Dated May 2017)

goodcompany Solar Panel Study

NC CLEAN ENERGY
TECHNOLOGY CENTER

NC STATE
UNIVERSITY

Health and Safety Impacts of Solar Photovoltaics

The increasing presence of utility-scale solar photovoltaic (PV) systems (sometimes referred to as solar farms) is a rather new development in North Carolina's landscape. Due to the new and unknown nature of this technology, it is natural for communities near such developments to be concerned about health and safety impacts. Unfortunately, the quick emergence of utility-scale solar has cultivated fertile grounds for myths and half-truths about the health impacts of this technology, which can lead to unnecessary fear and conflict.

Photovoltaic (PV) technologies and solar inverters are not known to pose any significant health dangers to their neighbors. The most important dangers posed are increased highway traffic during the relative short construction period and dangers posed to trespassers of contact with high voltage equipment. This latter risk is mitigated by signage and the security measures that industry uses to deter trespassing. As will be discussed in more detail below, risks of site contamination are much less than for most other industrial uses because PV technologies employ few toxic chemicals and those used are used in very small quantities. Due to the reduction in the pollution from fossil-fuel-fired electric generators, the overall impact of solar development on human health is overwhelmingly positive. This pollution reduction results from a partial replacement of fossil-fuel fired generation by emission-free PV-generated electricity, which reduces harmful sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$). Analysis from the National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory, both affiliates of the U.S. Department of Energy, estimates the health-related air quality benefits to the southeast region from solar PV generators to be worth 8.0 ¢ per kilowatt-hour of solar generation.[1] This is in addition to the value of the electricity and suggests that the air quality benefits of solar are worth more than the electricity itself.

Even though we have only recently seen large-scale installation of PV technologies, the technology and its potential impacts have been studied since the 1950s. A combination of this solar-specific research and general scientific research has led to the scientific community having a good understanding of the science behind potential health and safety impacts of solar energy. This paper utilizes the latest scientific literature and knowledge of solar practices in N.C. to address the health and safety risks associated with solar PV technology. These risks are extremely small, far less than those associated with common activities such as driving a car, and vastly outweighed by health benefits of the generation of clean electricity.

This paper addresses the potential health and safety impacts of solar PV development in North Carolina, organized into the following four categories:

(1) Hazardous Materials
(2) Electromagnetic Fields (EMF)
(3) Electric Shock and Arc Flash
(4) Fire Safety

1. Hazardous Materials

One of the more common concerns towards solar is that the panels (referred to as "modules" in the solar industry) consist of toxic materials that endanger public health. However, as shown in this section, solar energy systems may contain small amounts of toxic materials, but these materials do not endanger public health. To understand potential toxic hazards coming from a solar project, one must understand system installation, materials used, the panel end-of-life protocols, and system operation. This section will examine these aspects of a solar farm and the potential for toxicity impacts in the following subsections:

(1.2) Project Installation/Construction
(1.2) System Components
    1.2.1 Solar Panels: Construction and Durability
    1.2.2 Photovoltaic technologies
        (a) Crystalline Silicon
        (b) Cadmium Telluride (CdTe)
        (c) CIS/CIGS
    1.2.3 Panel End of Life Management
    1.2.4 Non-panel System Components
(1.3) Operations and Maintenance

1.1 Project Installation/Construction

The system installation, or construction, process does not require toxic chemicals or processes. The site is mechanically cleared of large vegetation, fences are constructed, and the land is surveyed to layout exact installation locations. Trenches for underground wiring are dug and support posts are driven into the ground. The solar panels are bolted to steel and aluminum support structures and wired together. Inverter pads are installed, and an inverter and transformer are installed on each pad. Once everything is connected, the system is tested, and only then turned on.

Figure 1: Utility-scale solar facility (5 MW_{AC}) located in Catawba County. Source: Strata Solar

1.2 System Components

1.2.1 Solar Panels: Construction and Durability

Solar PV panels typically consist of glass, polymer, aluminum, copper, and semiconductor materials that can be recovered and recycled at the end of their useful life. [2] Today there are two PV technologies used in PV panels at utility-scale solar facilities, silicon, and thin film. As of 2016, all thin film used in North Carolina solar facilities are cadmium telluride (CdTe) panels from the US manufacturer First Solar, but there are other thin film PV panels available on the market, such as Solar Frontier's CIGS panels. Crystalline silicon technology consists of silicon wafers which are made into cells and assembled into panels, thin film technologies consist of thin layers of semiconductor material deposited onto glass, polymer or metal substrates. While there are differences in the components and manufacturing processes of these two types of solar technologies, many aspects of their PV panel construction are very similar. Specifics about each type of PV chemistry as it relates to toxicity are covered in subsections a, b, and c in section 1.2.2; on crystalline silicon, cadmium telluride, and CIS/CIGS respectively. The rest of this section applies equally to both silicon and thin film panels.

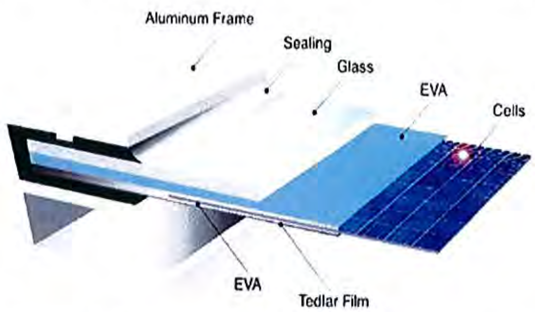


Figure 2: Components of crystalline silicon panels. The vast majority of silicon panels consist of a glass sheet on the topside with an aluminum frame providing structural support. Image Source: www.riteksolar.com.tw

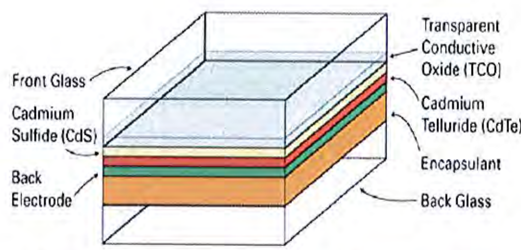


Figure 3: Layers of a common frameless thin-film panel (CdTe). Many thin film panels are frameless, including the most common thin-film panels, First Solar's CdTe. Frameless panels have protective glass on both the front and back of the panel. Layer thicknesses not to scale. Image Source: www.homepower.com

To provide decades of corrosion-free operation, PV cells in PV panels are encapsulated from air and moisture between two layers of plastic. The encapsulation layers are protected on the top with a layer of tempered glass and on the backside with a polymer sheet. Frameless modules include a protective layer of glass on the rear of the panel, which may also be tempered. The plastic ethylene-vinyl acetate (EVA) commonly provides the cell encapsulation. For decades, this same material has been used between layers of tempered glass to give car windshields and hurricane windows their great strength. In the same way that a car windshield cracks but stays intact, the EVA layers in PV panels keep broken panels intact (see Figure 4). Thus, a damaged module does not generally create small pieces of debris; instead, it largely remains together as one piece.

Figure 4: The mangled PV panels in this picture illustrate the nature of broken solar panels; the glass cracks but the panel is still in one piece. Image Source: http://img.alibaba.com/photo/115259576/broken_solar_panel.jpg

PV panels constructed with the same basic components as modern panels have been installed across the globe for well over thirty years.[3] The long-term durability and performance demonstrated over these decades, as well as the results of accelerated lifetime testing, helped lead to an industry-standard 25-year power production warranty for PV panels. These power warranties warrant a PV panel to produce at least 80% of their original nameplate production after 25 years of use. A recent SolarCity and DNV GL study reported that today's quality PV panels should be expected to reliably and efficiently produce power for thirty-five years.[4]

Local building codes require all structures, including ground mounted solar arrays, to be engineered to withstand anticipated wind speeds, as defined by the local wind speed requirements. Many racking products are available in versions engineered for wind speeds of up to 150 miles per hour, which is significantly higher than the wind speed requirement anywhere in North Carolina. The strength of PV mounting structures were demonstrated during Hurricane Sandy in 2012 and again during Hurricane Matthew in 2016. During Hurricane Sandy, the many large-scale solar facilities in New Jersey and New York at that time suffered only minor damage.[5] In the fall of 2016, the US and Caribbean experienced destructive winds and torrential rains from Hurricane Matthew, yet one leading solar tracker manufacturer reported that their numerous systems in the impacted area received zero damage from wind or flooding.[6]

In the event of a catastrophic event capable of damaging solar equipment, such as a tornado, the system will almost certainly have property insurance that will cover the cost to cleanup and repair the project. It is in the best interest of the system owner to protect their investment against such risks. It is also in their interest to get the project repaired and producing full power as soon as possible. Therefore, the investment in adequate insurance is a wise business practice for the system owner. For the same reasons, adequate insurance coverage is also generally a requirement of the bank or firm providing financing for the project.

1.2.2 Photovoltaic (PV) Technologies

a. **Crystalline Silicon**

This subsection explores the toxicity of silicon-based PV panels and concludes that they do not pose a material risk of toxicity to public health and safety. Modern crystalline silicon PV panels, which account for over 90% of solar PV panels installed today, are, more or less, a commodity product. The overwhelming majority of panels installed in North Carolina are crystalline silicon panels that are informally classified as Tier I panels. Tier I panels are from well-respected manufacturers that have a good chance of being able to honor warranty claims. Tier I panels are understood to be of high quality, with predictable performance, durability, and content. Well over 80% (by weight) of the content of a PV panel is the tempered glass front and the aluminum frame, both of which are common building materials. Most of the remaining portion are common plastics, including polyethylene terephthalate in the backsheet, EVA encapsulation of the PV cells, polyphenyl ether in the junction box, and polyethylene insulation on the wire leads. The active, working components of the system are the silicon photovoltaic cells, the small electrical leads connecting them together, and to the wires coming out of the back of the panel. The electricity generating and conducting components makeup less than 5% of the weight of most panels. The PV cell itself is nearly 100% silicon, and silicon is the second most common element in the Earth's crust. The silicon for PV cells is obtained by high-temperature processing of quartz sand (SiO_2) that removes its oxygen molecules. The refined silicon is converted to a PV cell by adding extremely small amounts of boron and phosphorus, both of which are common and of very low toxicity.

The other minor components of the PV cell are also generally benign; however, some contain lead, which is a human toxicant that is particularly harmful to young children. The minor components include an extremely thin antireflective coating (silicon nitride or titanium dioxide), a thin layer of aluminum on the rear, and thin strips of silver alloy that are screen-printed on the front and rear of cell.[7] In order for the front and rear electrodes to make effective electrical contact with the proper layer of the PV cell, other materials (called glass frit) are mixed with the silver alloy and then heated to etch the metals into the cell. This glass frit historically contains a small amount of lead (Pb) in the form of lead oxide. The 60 or 72 PV cells in a PV panel are connected by soldering thin solder-covered copper tabs from the back of one cell to the front of the next cell. Traditionally a tin-based solder containing some lead (Pb) is used, but some manufacturers have switched to lead-free solder. The glass frit and/or the solder may contain trace amounts of other metals, potentially including some with human toxicity such as cadmium. However, testing to simulate the potential for leaching from broken panels, which is discussed in more detail below, did not find a potential toxicity threat from these trace elements. Therefore, the tiny amount of lead in the grass frit and the solder is the only part of silicon PV panels with a potential to create a negative health impact. However, as described below, the very limited amount of lead involved and its strong physical and chemical attachment to other components of the PV panel means that even in worst-case scenarios the health hazard it poses is insignificant.

As with many electronic industries, the solder in silicon PV panels has historically been a lead-based solder, often 36% lead, due to the superior properties of such solder. However, recent advances in lead-free solders have spurred a trend among PV panel manufacturers to reduce or remove the lead in their panels. According to the 2015 Solar Scorecard from the Silicon Valley Toxics Coalition, a group that tracks environmental responsibility of photovoltaic panel manufacturers, fourteen companies (increased from twelve companies in 2014) manufacture PV panels certified to meet the European Restriction of

Hazardous Substances (RoHS) standard. This means that the amount of cadmium and lead in the panels they manufacture fall below the RoHS thresholds, which are set by the European Union and serve as the world's de facto standard for hazardous substances in manufactured goods.[8] The Restriction of Hazardous Substances (RoHS) standard requires that the maximum concentration found in any homogenous material in a produce is less than 0.01% cadmium and less than 0.10% lead, therefore, any solder can be no more than 0.10% lead.[9]

While some manufacturers are producing PV panels that meet the RoHS standard, there is no requirement that they do so because the RoHS Directive explicitly states that the directive does not apply to photovoltaic panels..[10] The justification for this is provided in item 17 of the current RoHS Directive: "The development of renewable forms of energy is one of the Union's key objectives, and the contribution made by renewable energy sources to environmental and climate objectives is crucial. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (4) recalls that there should be coherence between those objectives and other Union environmental legislation. Consequently, this Directive should not prevent the development of renewable energy technologies that have no negative impact on health and the environment and that are sustainable and economically viable."

The use of lead is common in our modern economy. However, only about 0.5% of the annual lead consumption in the U.S. is for electronic solder for all uses; PV solder makes up only a tiny portion of this 0.5%. Close to 90% of lead consumption in the US is in batteries, which do not encapsulate the pounds of lead contained in each typical automotive battery. This puts the lead in batteries at great risk of leaching into the environment. Estimates for the lead in a single PV panel with lead-based solder range from 1.6 to 24 grams of lead, with 13g (less than half of an ounce) per panel seen most often in the literature..[11] At 13 g/panel[12], each panel contains one-half of the lead in a typical 12-gauge shotgun shell. This amount equates to roughly 1/750th of the lead in a single car battery. In a panel, it is all durably encapsulated from air or water for the full life of the panel.[14]

As indicated by their 20 to 30-year power warranty, PV modules are designed for a long service life, generally over 25 years. For a panel to comply with its 25-year power warranty, its internal components, including lead, must be sealed from any moisture. Otherwise, they would corrode and the panel's output would fall below power warranty levels. Thus, the lead in operating PV modules is not at risk of release to the environment during their service lifetime. In extreme experiments, researchers have shown that lead can leach from crushed or pulverized panels.[15, 16] However, more real-world tests designed to represent typical trash compaction that are used to classify waste as hazardous or non-hazardous show no danger from leaching.[17, 18] For more information about PV panel end-of-life, see the Panel Disposal section.

As illustrated throughout this section, silicon-based PV panels do not pose a material threat to public health and safety. The only aspect of the panels with potential toxicity concerns is the very small amount of lead in some panels. However, any lead in a panel is well sealed from environmental exposure for the operating lifetime of the solar panel and thus not at risk of release into the environment.

b. Cadmium Telluride (CdTe) PV Panels

This subsection examines the components of a cadmium telluride (CdTe) PV panel. Research demonstrates that they pose negligible toxicity risk to public health and safety while significantly reducing the public's exposure to cadmium by reducing coal emissions. As of mid-2016, a few hundred MWs of cadmium telluride (CdTe) panels, all manufactured by the U.S. company First Solar, have been installed in North Carolina.

Questions about the potential health and environmental impacts from the use of this PV technology are related to the concern that these panels contain cadmium, a toxic heavy metal. However, scientific studies have shown that cadmium telluride differs from cadmium due to its high chemical and thermal stability.[19] Research has shown that the tiny amount of cadmium in these panels does not pose a health or safety risk.[20] Further, there are very compelling reasons to welcome its adoption due to reductions in unhealthy pollution associated with burning coal. Every GWh of electricity generated by burning coal produces about 4 grams of cadmium air emissions.[21] Even though North Carolina produces a significant fraction of our electricity from coal, electricity from solar offsets much more natural gas than coal due to natural gas plants being able to adjust their rate of production more easily and quickly. If solar electricity offsets 90% natural gas and 10% coal, each 5-megawatt (5 MW_{AC}, which is generally 7 MW_{DC}) CdTe solar facility in North Carolina keeps about 157 grams, or about a third of a pound, of cadmium *out of* our environment.[22, 23]

Cadmium is toxic, but all the approximately 7 grams of cadmium in one CdTe panel is in the form of a chemical compound cadmium telluride,[24] which has 1/100th the toxicity of free cadmium.[25] Cadmium telluride is a very stable compound that is non-volatile and non-soluble in water. Even in the case of a fire, research shows that less than 0.1% of the cadmium is released when a CdTe panel is exposed to fire. The fire melts the glass and encapsulates over 99.9% of the cadmium in the molten glass.[27]

It is important to understand the source of the cadmium used to manufacture CdTe PV panels. The cadmium is a byproduct of zinc and lead refining. The element is collected from emissions and waste streams during the production of these metals and combined with tellurium to create the CdTe used in PV panels. If the cadmium were not collected for use in the PV panels or other products, it would otherwise either be stockpiled for future use, cemented and buried, or disposed of.[28] Nearly all the cadmium in old or broken panels can be recycled which can eventually serve as the primary source of cadmium for new PV panels.[29]

Similar to silicon-based PV panels, CdTe panels are constructed of a tempered glass front, one instead of two clear plastic encapsulation layers, and a rear heat strengthened glass backing (together >98% by weight). The final product is built to withstand exposure to the elements without significant damage for over 25 years. While not representative of damage that may occur in the field or even at a landfill, laboratory evidence has illustrated that when panels are ground into a fine powder, very acidic water is able to leach portions of the cadmium and tellurium,[30] similar to the process used to recycle CdTe panels. Like many silicon-based panels, CdTe panels are reported (as far back ask 1998[31]) to pass the EPA's Toxic Characteristic Leaching Procedure (TCLP) test, which tests the potential for crushed panels in a landfill to leach hazardous substances into groundwater.[32] Passing this test means that they are classified as non-hazardous waste and can be deposited in landfills.[33,34] For more information about PV panel end-of-life, see the Panel Disposal section.

There is also concern of environmental impact resulting from potential catastrophic events involving CdTe PV panels. An analysis of worst-case scenarios for environmental impact from CdTe PV panels, including earthquakes, fires, and floods, was conducted by the University of Tokyo in 2013. After reviewing the extensive international body of research on CdTe PV technology, their report concluded, "Even in the worst-case scenarios, it is unlikely that the Cd concentrations in air and sea water will exceed the environmental regulation values."[35] In a worst-case scenario of damaged panels abandoned on the ground, insignificant amounts of cadmium will leach from the panels. This is because this scenario is much less conducive (larger module pieces, less acidity) to leaching than the conditions of the EPA's TCLP test used to simulate landfill conditions, which CdTe panels pass.[36]

First Solar, a U.S. company, and the only significant supplier of CdTe panels, has a robust panel take-back and recycling program that has been operating commercially since 2005.[37] The company states that it is "committed to providing a commercially attractive recycling solution for photovoltaic (PV) power plant and module owners to help them meet their module (end of life) EOL obligation simply, cost-effectively and responsibly." First Solar global recycling services to their customers to collect and recycle panels once they reach the end of productive life whether due to age or damage. These recycling service agreements are structured to be financially attractive to both First Solar and the solar panel owner. For First Solar, the contract provides the company with an affordable source of raw materials needed for new panels and presumably a diminished risk of undesired release of Cd. The contract also benefits the solar panel owner by allowing them to avoid tipping fees at a waste disposal site. The legal contract helps provide peace of mind by ensuring compliance by both parties when considering the continuing trend of rising disposal costs and increasing regulatory requirements.

c. **CIS/CIGS and other PV technologies**

Copper indium gallium selenide PV technology, often referred to as CIGS, is the second most common type of thin-film PV panel but a distant second behind CdTe. CIGS cells are composed of a thin layer of copper, indium, gallium, and selenium on a glass or plastic backing. None of these elements are very toxic, although selenium is a regulated metal under the Federal Resource Conservation and Recovery Act (RCRA).[38] The cells often also have an extremely thin layer of cadmium sulfide that contains a tiny amount of cadmium, which is toxic. The promise of high efficiency CIGS panels drove heavy investment in this technology in the past. However, researchers have struggled to transfer high efficiency success in the lab to low-cost full-scale panels in the field.[39] Recently, a CIGS manufacturer based in Japan, Solar Frontier, has achieved some market success with a rigid, glass-faced CIGS module that competes with silicon panels. Solar Frontier produces the majority of CIS panels on the market today.[40] Notably, these panels are RoHS compliant,[41] thus meeting the rigorous toxicity standard adopted by the European Union even thought this directive exempts PV panels. The authors are unaware of any completed or proposed utility-scale system in North Carolina using CIS/CIGS panels.

1.2.3 Panel End-of-Life Management

Concerns about the volume, disposal, toxicity, and recycling of PV panels are addressed in this subsection. To put the volume of PV waste into perspective, consider that by 2050, when PV systems installed in 2020 will reach the end of their lives, it is estimated that the global annual PV panel waste tonnage will be 10% of the 2014 global e-waste tonnage.[42] In the U.S., end-of-life disposal of solar products is governed by the Federal Resource Conservation and Recovery Act (RCRA), as well as state policies in some situations. RCRA separates waste into hazardous (not accepted at ordinary landfill) and solid waste (generally accepted at ordinary landfill) based on a series of rules. According to RCRA, the way to determine if a PV panel is classified as hazardous waste is the Toxic Characteristic Leaching Procedure (TCLP) test. This EPA test is designed to simulate landfill disposal and determine the risk of hazardous substances leaching out of the landfill.[43,44,45] Multiple sources report that most modern PV panels (both crystalline silicon and cadmium telluride) pass the TCLP test.[46,47] Some studies found that some older (1990s) crystalline silicon panels, and perhaps some newer crystalline silicon panels (specifics are not given about vintage of panels tested), do not pass the lead (Pb) leachate limits in the TCLP test.[48,49]

The test begins with the crushing of a panel into centimeter-sized pieces. The pieces are then mixed in an acid bath. After tumbling for eighteen hours, the fluid is tested for forty hazardous substances that all must be below specific threshold levels to pass the test. Research comparing TCLP conditions to conditions of damaged panels in the field found that simulated landfill conditions provide overly conservative estimates of leaching for field-damaged panels.[50] Additionally, research in Japan has found no detectable Cd leaching from cracked CdTe panels when exposed to simulated acid rain.[51]

Although modern panels can generally be landfilled, they can also be recycled. Even though recent waste volume has not been adequate to support significant PV-specific recycling infrastructure, the existing recycling industry in North Carolina reports that it recycles much of the current small volume of broken PV panels. In an informal survey conducted by the NC Clean Energy Technology Center survey in early 2016, seven of the eight large active North Carolina utility-scale solar developers surveyed reported that they send damaged panels back to the manufacturer and/or to a local recycler. Only one developer reported sending damaged panels to the landfill.

The developers reported at that time that they are usually paid a small amount per panel by local recycling firms. In early 2017, a PV developer reported that a local recycler was charging a small fee per panel to recycle damaged PV panels. The local recycling firm known to authors to accept PV panels described their current PV panel recycling practice as of early 2016 as removing the aluminum frame for local recycling and removing the wire leads for local copper recycling. The remainder of the panel is sent to a facility for processing the non-metallic portions of crushed vehicles, referred to as "fluff" in the recycling industry.[52] This processing within existing general recycling plants allows for significant material recovery of major components, including glass which is 80% of the module weight, but at lower yields than PV-specific recycling plants. Notably almost half of the material value in a PV panel is in the few grams of silver contained in almost every PV panel produced today. In the long-term, dedicated PV panel recycling plants can increase treatment capacities and maximize revenues resulting in better output quality and the ability to recover a greater fraction of the useful materials..[53] PV-specific panel recycling technologies have been researched and implemented to some extent for the past decade, and have been shown to be able to recover over 95% of PV material (semiconductor) and over 90% of the glass in a PV panel.[54]

A look at global PV recycling trends hints at the future possibilities of the practice in our country. Europe installed MW-scale volumes of PV years before the U.S. In 2007, a public-private partnership between the European Union and the solar industry set up a voluntary collection and recycling system called PV CYCLE. This arrangement was later made mandatory under the EU's WEEE directive, a program for waste electrical and electronic equipment.[55] Its member companies (PV panel producers) fully finance the association. This makes it possible for end-users to return the member companies' defective panels for recycling at any of the over 300 collection points around Europe without added costs. Additionally, PV CYCLE will pick up batches of 40 or more used panels at no cost to the user. This arrangement has been very successful, collecting and recycling over 13,000 tons by the end of 2015..[56]

In 2012, the WEEE Directive added the end-of-life collection and recycling of PV panels to its scope.[57] This directive is based on the principle of extended-producer-responsibility. It has a global impact because producers that want to sell into the EU market are legally responsible for end-of-life management. Starting in 2018, this directive targets that 85% of PV products "put in the market" in Europe are recovered and 80% is prepared for reuse and recycling.

The success of the PV panel collection and recycling practices in Europe provides promise for the future of recycling in the U.S. In mid-2016, the US Solar Energy Industry Association (SEIA) announced that they are starting a national solar panel recycling program with the guidance and support of many leading PV panel producers.[58] The program will aggregate the services offered by recycling vendors and PV manufacturers, which will make it easier for consumers to select a cost-effective and environmentally responsible end-of-life management solution for their PV products. According to SEIA, they are planning the program in an effort to make the entire industry landfill-free. In addition to the national recycling network program, the program will provide a portal for system owners and consumers with information on how to responsibly recycle their PV systems.

While a cautious approach toward the potential for negative environmental and/or health impacts from retired PV panels is fully warranted, this section has shown that the positive health impacts of reduced emissions from fossil fuel combustion from PV systems more than outweighs any potential risk. Testing shows that silicon and CdTe panels are both safe to dispose of in landfills, and are also safe in worst case conditions of abandonment or damage in a disaster. Additionally, analysis by local engineers has found that the current salvage value of the equipment in a utility scale PV facility generally exceeds general contractor estimates for the cost to remove the entire PV system.[59, 60, 61]

1.2.4 Non-Panel System Components (racking, wiring, inverter, transformer)

While previous toxicity subsections discussed PV panels, this subsection describes the non-panel components of utility-scale PV systems and investigates any potential public health and safety concerns. The most significant non-panel component of a ground-mounted PV system is the mounting structure of the rows of panels, commonly referred to as "racking". The vertical post portion of the racking is galvanized steel and the remaining above-ground racking components are either galvanized steel or aluminum, which are both extremely common and benign building materials. The inverters that make the solar generated electricity ready to send to the grid have weather-proof steel enclosures that protect the working components from the elements. The only fluids that they might contain are associated with their cooling systems, which are not unlike the cooling system in a computer. Many inverters today are RoHS compliant.

The electrical transformers (to boost the inverter output voltage to the voltage of the utility connection point) do contain a liquid cooling oil. However, the fluid used for that function is either a non-toxic mineral oil or a biodegradable non-toxic vegetable oil, such as BIOTEMP from ABB. These vegetable transformer oils have the additional advantage of being much less flammable than traditional mineral oils. Significant health hazards are associated with old transformers containing cooling oil with toxic PCBs. Transfers with PCB-containing oil were common before PCBs were outlawed in the U.S. in 1979. PCBs still exist in older transformers in the field across the country.

Other than a few utility research sites, there are no batteries on- or off-site associated with utility-scale solar energy facilities in North Carolina, avoiding any potential health or safety concerns related to battery technologies. However, as battery technologies continue to improve and prices continue to decline we are likely to start seeing some batteries at solar facilities. Lithium ion batteries currently dominate the world utility-scale battery market, which are not very toxic. No non-panel system components were found to pose any health or environmental dangers.

1.4 Operations and Maintenance – Panel Washing and Vegetation Control

Throughout the eastern U.S., the climate provides frequent and heavy enough rain to keep panels adequately clean. This dependable weather pattern eliminates the need to wash the panels on a regular basis. Some system owners may choose to wash panels as often as once a year to increase production, but most in N.C. do not regularly wash any PV panels. Dirt build up over time may justify panel washing a few times over the panels' lifetime; however, nothing more than soap and water are required for this activity.

The maintenance of ground-mounted PV facilities requires that vegetation be kept low, both for aesthetics and to avoid shading of the PV panels. Several approaches are used to maintain vegetation at NC solar facilities, including planting of limited-height species, mowing, weed-eating, herbicides, and grazing livestock (sheep). The following descriptions of vegetation maintenance practices are based on interviews with several solar developers as well as with three maintenance firms that together are contracted to maintain well over 100 of the solar facilities in N.C. The majority of solar facilities in North Carolina maintain vegetation primarily by mowing. Each row of panels has a single row of supports, allowing sickle mowers to mow under the panels. The sites usually require mowing about once a month during the growing season. Some sites employ sheep to graze the site, which greatly reduces the human effort required to maintain the vegetation and produces high quality lamb meat.[62]

In addition to mowing and weed eating, solar facilities often use some herbicides. Solar facilities generally do not spray herbicides over the entire acreage; rather they apply them only in strategic locations such as at the base of the perimeter fence, around exterior vegetative buffer, on interior dirt roads, and near the panel support posts. Also unlike many row crop operations, solar facilities generally use only general use herbicides, which are available over the counter, as opposed to restricted use herbicides commonly used in commercial agriculture that require a special restricted use license. The herbicides used at solar facilities are primarily 2-4-D and glyphosate (Round-up®), which are two of the most common herbicides used in lawns, parks, and agriculture across the country. One maintenance firm that was interviewed sprays the grass with a class of herbicide known as a growth regulator in order to slow the growth of grass so that mowing is only required twice a year. Growth regulators are commonly used on highway roadsides and golf courses for the same purpose. A commercial pesticide applicator license is required for anyone other than the landowner to apply herbicides, which helps ensure that all applicators are adequately educated about proper herbicide use and application. The license must be renewed annually and requires passing of a certification exam appropriate to the area in which the applicator wishes to work. Based on the limited data available, it appears that solar facilities in N.C. generally use significantly less herbicides per acre than most commercial agriculture or lawn maintenance services.

2. Electromagnetic Fields (EMF)

PV systems do not emit any material during their operation; however, they do generate electromagnetic fields (EMF), sometimes referred to as radiation. EMF produced by electricity is non-ionizing radiation, meaning the radiation has enough energy to move atoms in a molecule around (experienced as heat), but not enough energy to remove electrons from an atom or molecule (ionize) or to damage DNA. As shown below, modern humans are all exposed to EMF throughout our daily lives without negative health impact. Someone outside of the fenced perimeter of a solar facility is not exposed to significant EMF from the solar facility. Therefore, there is no negative health impact from the EMF produced in a solar farm. The following paragraphs provide some additional background and detail to support this conclusion.

Since the 1970s, some have expressed concern over potential health consequences of EMF from electricity, but no studies have ever shown this EMF to cause health problems.[63] These concerns are based on some epidemiological studies that found a slight increase in childhood leukemia associated with average exposure to residential power-frequency magnetic fields above 0.3 to 0.4 μT (microteslas) (equal to 3.0 to 4.0 mG (milligauss)). μT and mG are both units used to measure magnetic field strength. For comparison, the average exposure for people in the U.S. is one mG or 0.1 μT, with about 1% of the population with an average exposure in excess of 0.4 μT (or 4 mG).[64] These epidemiological studies, which found an association but not a causal relationship, led the World Health Organization's International Agency for Research on Cancer (IARC) to classify ELF magnetic fields as "possibly carcinogenic to humans". Coffee also has this classification. This classification means there is limited evidence but not enough evidence to designate as either a "probable carcinogen" or "human carcinogen". Overall, there is very little concern that ELF EMF damages public health. The only concern that does exist is for long-term exposure above 0.4 μT (4 mG) that may have some connection to increased cases of childhood leukemia. In 1997, the National Academies of Science were directed by Congress to examine this concern and concluded:

> "Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."[65]

There are two aspects to electromagnetic fields, an electric field and a magnetic field. The electric field is generated by voltage and the magnetic field is generated by electric current, i.e., moving electrons. A task group of scientific experts convened by the World Health Organization (WHO) in 2005 concluded that there were no substantive health issues related to *electric* fields (0 to 100,000 Hz) at levels generally encountered by members of the public.[66] The relatively low voltages in a solar facility and the fact that electric fields are easily shielded (i.e., blocked) by common materials, such as plastic, metal, or soil means that there is no concern of negative health impacts from the electric fields generated by a solar facility. Thus, the remainder of this section addresses magnetic fields. Magnetic fields are not shielded by most common materials and thus can easily pass through them. Both types of fields are strongest close to the source of electric generation and weaken quickly with distance from the source.

The direct current (DC) electricity produced by PV panels produce stationary (0 Hz) electric and magnetic fields. Because of minimal concern about potential risks of stationary fields, little scientific research has examined stationary fields' impact on human health.[67] In even the largest PV facilities, the DC voltages and currents are not very high. One can illustrate the weakness of the EMF generated by a PV panel by placing a compass on an operating solar panel and observing that the needle still points north.

While the electricity throughout the majority of a solar site is DC electricity, the inverters convert this DC electricity to alternating current (AC) electricity matching the 60 Hz frequency of the grid. Therefore, the inverters and the wires delivering this power to the grid are producing non-stationary EMF, known as extremely low frequency (ELF) EMF, normally oscillating with a frequency of 60 Hz. This frequency is at the low-energy end of the electromagnetic spectrum. Therefore, it has less energy than other commonly encountered types of non-ionizing radiation like radio waves, infrared radiation, and visible light.

The wide use of electricity results in background levels of ELF EMFs in nearly all locations where people spend time – homes, workplaces, schools, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there.[68] As stated above, the average exposure to magnetic fields in the U.S. is estimated to be around one mG or 0.1 μT, but can vary considerably depending on a person's exposure to EMF from electrical devices and wiring.[69] At times we are often exposed to much higher ELF magnetic fields, for example when standing three feet from a refrigerator the ELF magnetic field is 6 mG and when standing three feet from a microwave oven the field is about 50 mG.[70] The strength of these fields diminish quickly with distance from the source, but when surrounded by electricity in our homes and other buildings moving away from one source moves you closer to another. However, unless you are inside of the fence at a utility-scale solar facility or electrical substation it is impossible to get very close to the EMF sources. Because of this, EMF levels at the fence of electrical substations containing high voltages and currents are considered "generally negligible".[71, 72]

The strength of ELF-EMF present at the perimeter of a solar facility or near a PV system in a commercial or residential building is significantly lower than the typical American's average EMF exposure.[73,74] Researchers in Massachusetts measured magnetic fields at PV projects and found the magnetic fields dropped to very low levels of 0.5 mG or less, and in many cases to less than background levels (0.2 mG), at distances of no more than nine feet from the residential inverters and 150 feet from the utility-scale inverters.[75] Even when measured within a few feet of the utility-scale inverter, the ELF magnetic fields were well below the International Commission on Non-Ionizing Radiation Protection's recommended magnetic field level exposure limit for the general public of 2,000 mG.[76] It is typical that utility scale designs locate large inverters central to the PV panels that feed them because this minimizes the length of wire required and shields neighbors from the sound of the inverter's cooling fans. Thus, it is rare for a large PV inverter to be within 150 feet of the project's security fence.

Anyone relying on a medical device such as pacemaker or other implanted device to maintain proper heart rhythm may have concern about the potential for a solar project to interfere with the operation of his or her device. However, there is no reason for concern because the EMF outside of the solar facility's fence is less than 1/1000 of the level at which manufacturers test for ELF EMF interference, which is 1,000 mG.[77] Manufacturers of potentially affected implanted devices often provide advice on electromagnetic interference that includes avoiding letting the implanted device get too close to certain sources of fields such as some household appliances, some walkie-talkies, and similar transmitting devices. Some manufacturers' literature does not mention high-voltage power lines, some say that exposure in public areas should not give interference, and some advise not spending extended periods of time close to power lines.[78]

3. Electric Shock and Arc Flash Hazards

There is a real danger of electric shock to anyone entering any of the electrical cabinets such as combiner boxes, disconnect switches, inverters, or transformers; or otherwise coming in contact with voltages over 50 Volts.[79] Another electrical hazard is an arc flash, which is an explosion of energy that can occur in a short circuit situation. This explosive release of energy causes a flash of heat and a shockwave, both of which can cause serious injury or death. Properly trained and equipped technicians and electricians know how to safely install, test, and repair PV systems, but there is always some risk of injury when hazardous voltages and/or currents are present. Untrained individuals should not attempt to inspect, test, or repair any aspect of a PV system due to the potential for injury or death due to electric shock and arc flash, The National Electric Code (NEC) requires appropriate levels of warning signs on all electrical components based on the level of danger determined by the voltages and current potentials. The national electric code also requires the site to be secured from unauthorized visitors with either a six-foot chain link fence with three strands of barbed wire or an eight-foot fence, both with adequate hazard warning signs.

4. Fire Safety

The possibility of fires resulting from or intensified by PV systems may trigger concern among the general public as well as among firefighters. However, concern over solar fire hazards should be limited because only a small portion of materials in the panels are flammable, and those components cannot self-support a significant fire. Flammable components of PV panels include the thin layers of polymer encapsulates surrounding the PV cells, polymer backsheets (framed panels only), plastic junction boxes on rear of panel, and insulation on wiring. The rest of the panel is composed of non-flammable components, notably including one or two layers of protective glass that make up over three quarters of the panel's weight.

Heat from a small flame is not adequate to ignite a PV panel, but heat from a more intense fire or energy from an electrical fault can ignite a PV panel..[80] One real-world example of this occurred during July 2015 in an arid area of California. Three acres of grass under a thin film PV facility burned without igniting the panels mounted on fixed-tilt racks just above the grass..[81] While it is possible for electrical faults in PV systems on homes or commercial buildings to start a fire, this is extremely rare. [82] Improving understanding of the PV-specific risks, safer system designs, and updated fire-related codes and standards will continue to reduce the risk of fire caused by PV systems.

PV systems on buildings can affect firefighters in two primary ways, 1) impact their methods of fighting the fire, and 2) pose safety hazard to the firefighters. One of the most important techniques that firefighters use to suppress fire is ventilation of a building's roof. This technique allows superheated toxic gases to quickly exit the building. By doing so, the firefighters gain easier and safer access to the building, Ventilation of the roof also makes the challenge of putting out the fire easier. However, the placement of rooftop PV panels may interfere with ventilating the roof by limiting access to desired venting locations.

New solar-specific building code requirements are working to minimize these concerns. Also, the latest National Electric Code has added requirements that make it easier for first responders to safely and effectively turn off a PV system. Concern for firefighting a building with PV can be reduced with proper fire fighter training, system design, and installation. Numerous organizations have studied fire fighter safety related to PV. Many organizations have published valuable guides and training programs. Some notable examples are listed below.

- The International Association of Fire Fighters (IAFF) and International Renewable Energy Council (IREC) partnered to create an online training course that is far beyond the PowerPoint click-and-view model. The self-paced online course, "Solar PV Safety for Fire Fighters," features rich video content and simulated environments so fire fighters can practice the knowledge they've learned. www.iaff.org/pvsafetytraining
- Photovoltaic Systems and the Fire Code: Office of NC Fire Marshal
- Fire Service Training, Underwriter's Laboratory

- Firefighter Safety and Response for Solar Power Systems, National Fire Protection Research Foundation
- Bridging the Gap: Fire Safety & Green Buildings, National Association of State Fire Marshalls
- Guidelines for Fire Safety Elements of Solar Photovoltaic Systems, Orange County Fire Chiefs Association
- Solar Photovoltaic Installation Guidelines, California Department of Forestry & Fire Protection, Office of the State Fire Marshall
- PV Safety & Firefighting, Matthew Paiss, Homepower Magazine
- PV Safety and Code Development: Matthew Paiss, Cooperative Research Network

Summary

The purpose of this paper is to address and alleviate concerns of public health and safety for utility-scale solar PV projects. Concerns of public health and safety were divided and discussed in the four following sections: (1) Toxicity, (2) Electromagnetic Fields, (3) Electric Shock and Arc Flash, and (4) Fire. In each of these sections, the negative health and safety impacts of utility-scale PV development were shown to be negligible, while the public health and safety benefits of installing these facilities are significant and far outweigh any negative impacts.

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[1] Wiser, Ryan, Trieu Mai, Dev Millstein, Jordan Macknick, Alberta Carpenter, Stuart Cohen, Wesley Cole, Bethany Frew, and Garvin A. Heath. 2016. On the Path to SunShot: The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the United States. Golden, CO: National Renewable Energy Laboratory. Accessed March 2017, www.nrel.gov/docs/fy16osti/65628.pdf

[2] IRENA and IEA-PVPS (2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems.

[3] National Renewable Energy Laboratory, *Overview of Field Experience – Degradation Rates & Lifetimes*. September 14, 2015. Solar Power International Conference. Accessed March 2017, www.nrel.gov/docs/fy15osti/65040.pdf

[4] Miesel et al. *SolarCity Photovoltaic Modules with 35 Year Useful Life.* June 2016. Accessed March 2017. http://www.solarcity.com/newsroom/reports/solarcity-photovoltaic-modules-35-year-useful-life

[5] David Unger. *Are Renewables Stormproof? Hurricane Sandy Tests Solar, Wind.* November 2012. Accessed March 2017. http://www.csmonitor.com/Environment/Energy-Voices/2012/1119/Are-renewables-stormproof-Hurricane-Sandy-tests-solar-wind & http://www.csmonitor.com/Environment/Energy-Voices/2012/1119/Are-renewables-stormproof-Hurricane-Sandy-tests-solar-wind

[6] NEXTracker and 365 Pronto, *Tracking Your Solar Investment: Best Practices for Solar Tracker O&M.* Accessed March 2017. www.nextracker.com/content/uploads/2017/03/NEXTracker_OandM-WhitePaper_FINAL_March-2017.pdf

[7] Christiana Honsberg, Stuart Bowden. *Overview of Screen Printed Solar Cells.* Accessed January 2017. www.pveducation.org/pvcdrom/manufacturing/screen-printed

[8] Silicon Valley Toxics Coalition. *2015 Solar Scorecard.* Accessed August 2016. www.solarscorecard.com/2015/2015-SVTC-Solar-Scorecard.pdf

[9] European Commission. *Recast of Reduction of Hazardous Substances (RoHS) Directive.* September 2016. Accessed August 2016. http://ec.europa.eu/environment/waste/rohs_eee/index_en.htm

[10] Official Journal of the European Union, *DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.* June 2011. Accessed May 2017. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065&from=en

[11] Giancarlo Giacchetta, Mariella Leporini, Barbara Marchetti. *Evaluation of the Environmental Benefits of New High Value Process for the Management of the End of Life of Thin Film Photovoltaic Modules.* July 2013. Accessed August 2016. www.researchgate.net/publication/257408804_Evaluation_of_the_environmental_benefits_of_new_high_value_process_for_the_management_of_the_end_of_life_of_thin_film_photovoltaic_modules

[12] European Commission. *Study on Photovoltaic Panels Supplementing The Impact Assessment for a Recast of the Weee Directive.* April 2011. Accessed August 2016. http://ec.europa.eu/environment/waste/weee/pdf/Study%20on%20PVs%20Bio%20final.pdf

[14] The amount of lead in a typical car battery is 21.4 pounds. Waste 360. Chaz Miller. *Lead Acid Batteries.* March 2006. Accessed August 2016. http://waste360.com/mag/waste_leadacid_batteries_3

[15] Okkenhaug G. *Leaching from CdTe PV module material results from batch, column and availability tests.* Norwegian Geotechnical Institute, NGI report No. 20092155-00-6-R; 2010

[16] International Journal of Advanced Applied Physics Research. Renate Zapf-Gottwick1, et al. *Leaching Hazardous Substances out of Photovoltaic Modules.* January 2015. Accessed January 2016. www.cosmosscholars.com/phms/index.php/ijaapr/article/download/485/298

[17] ibid

[18] Parikhit Sinha, et al. Evaluation of Potential Health and Environmental Impacts from End-Of-Life Disposal of Photovoltaics, Photovoltaics, 2014. Accessed May 2016

[19] Bonnet, D. and P. Meyers. 1998. *Cadmium-telluride—Material for thin film solar cells.* J. Mater. Res., Vol. 13, No. 10, pp. 2740-2753

[20] V. Fthenakis, K. Zweibel. *CdTe PV: Real and Perceived EHS Risks.* National Center ofr Photovoltaics and Solar Program Review Meeting, March 24-26, 2003. www.nrel.gov/docs/fy03osti/33561.pdf. Accessed May 2017

[21] International Energy Agency Photovoltaic Power Systems Programme. *Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems.* March 2015. Accessed August 2016. http://iea-pvps.org/index.php?id=315

[22] Data not available on fraction of various generation sources offset by solar generation in NC, but this is believed to be a reasonable rough estimate. The SunShot report entitled The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the United States analysis contributes significant (% not provided) offsetting of coal-fired generation by solar PV energy in the southeast.

[23] 7 MW_{DC} * 1.5 GWh/MW_{DC} * 25 years * 0.93 degradation factor * (0.1 *4.65 grams/GWh + 0.9*0.2 grams/GWh)

[24] Vasilis Fthenakis. *CdTe PV: Facts and Handy Comparisons.* January 2003. Accessed March 2017. https://www.bnl.gov/pv/files/pdf/art_165.pdf

[25] Kaczmar, S., *Evaluating the Read-Across Approach on CdTe Toxicity for CdTe Photovoltaics*, SETAC North America 32nd Annual Meeting, Boston, MA, November 2011. Available at: ftp://ftp.co.imperial.ca.us/icpds/eir/campo-verde-solar/final/evaluating-toxicity.pdf, Accessed May 2017

[27] V. M. Fthenakis et al, *Emissions and Encapsulation of Cadmium in CdTe PV Modules During Fires* Renewable Progress in Photovoltaics: Research and Application: Res. Appl. 2005; 13:1–11, Accessed March 2017, www.bnl.gov/pv/files/pdf/abs_179.pdf

[28] Fthenakis *V.M., Life Cycle Impact Analysis of Cadmium in CdTe Photovoltaic Production*, Renewable and Sustainable Energy Reviews, 8, 303-334, 2004. www.clca.columbia.edu/papers/Life_Cycle_Impact_Analysis_Cadmium_CdTe_Photovoltaic_production.pdf, Accessed May 2017

[29] International Renewable Energy Agency. Stephanie Weckend, Andreas Wade, Garvin Heath. *End of Life Management: Solar Photovoltaic Panels.* June 2016. Accessed November 2016.

[30] International Journal of Advanced Applied Physics Research. Renate Zapf-Gottwick1, et al. *Leaching Hazardous Substances out of Photovoltaic Modules.* January 2015. Accessed January 2016. www.cosmosscholars.com/phms/index.php/ijaapr/article/download/485/298

[31] Cunningham D., Discussion about TCLP protocols, Photovoltaics and the Environment Workshop, July 23-24, 1998, Brookhaven National Laboratory, BNL-52557

[32] Parikhit Sinha, et al. Evaluation of Potential Health and Environmental Impacts from End-Of-Life Disposal of Photovoltaics, Photovoltaics, 2014. Accessed May 2016

[33] Practical Handbook of Photovoltaics: Fundamentals and Applications. T. Markvart and L. Castaner. *Chapter VII-2: Overview of Potential Hazards.* December 2003. Accessed August 2016. https://www.bnl.gov/pv/files/pdf/art_170.pdf

[34] Norwegian Geotechnical Institute. *Environmental Risks Regarding the Use and End-of-Life Disposal of CdTe PV Modules.* April 2010. Accessed August 2016. https://www.dtsc.ca.gov/LawsRegsPolicies/upload/Norwegian-Geotechnical-Institute-Study.pdf

[35] First Solar. Dr. Yasunari Matsuno. December 2013. August 2016. *Environmental Risk Assessment of CdTe PV Systems to be considered under Catastrophic Events in Japan.* http://www.firstsolar.com/-/media/Documents/Sustainability/Peer-Reviews/Japan_Peer-Review_Matsuno_CdTe-PV-Tsunami.ashx

[36] First Solar. Parikhit Sinha, Andreas Wade. *Assessment of Leaching Tests for Evaluating Potential Environmental Impacts of PV Module Field Breakage.* 2015 IEEE

[37] See p. 22 of First Solar, Sustainability Report. Available at: www.firstsolar.com/-/media/First-Solar/Sustainability-Documents/03801_FirstSolar_SustainabilityReport_08MAR16_Web.ashx, Accessed May 2017

[38] 40 CFR §261.24. *Toxicity Characteristic.* May 2017. Accessed May 2017. https://www.ecfr.gov/cgi-bin/text-idx?node=se40.26.261_124&rgn=div8
[39] Office of Energy Efficiency & Renewable Energy. *Copper Indium Gallium Diselenide.* Accessed March 2017. https://www.energy.gov/eere/sunshot/copper-indium-gallium-diselenide
[40] Mathias Maehlum. *Best Thin Film Solar Panels – Amorphous, Cadmium Telluride or CIGS?* April 2015. Accessed March 2017. http://energyinformative.org/best-thin-film-solar-panels-amorphous-cadmium-telluride-cigs/
[41] RoHS tested certificate for Solar Frontier PV modules. TUVRheinland, signed 11.11.2013
[42] International Renewable Energy Agency. Stephanie Weckend, Andreas Wade, Garvin Heath. *End of Life Management: Solar Photovoltaic Panels.* June 2016. Accessed November 2016. http://www.irena.org/DocumentDownloads/Publications/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf
[43] 40 C.F.R. §261.10. *Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste.* November 2016. Accessed November 2016 http://www.ecfr.gov/cgi-bin/text-idx?SID=ce0006d66da40146b490084ca2816143&mc=true&node=pt40.26.261&rgn=div5#sp40.28.261.b
[44] 40 C.F.R. §261.24 *Toxicity Characteristic.* November 2016. Accessed November 2016. http://www.ecfr.gov/cgi-bin/text-idx?SID=ce0006d66da40146b490084ca2816143&mc=true&node=pt40.26.261&rgn=div5#se40.28.261_124
[45] International Renewable Energy Agency. Stephanie Weckend, Andreas Wade, Garvin Heath. *End of Life Management: Solar Photovoltaic Panels.* June 2016. Accessed November 2016. http://www.irena.org/DocumentDownloads/Publications/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf
[46] TLCP test results from third-party laboratories for REC, Jinko, and Canadian Solar silicon-based panels. Provided by PV panel manufacturers directly or indirectly to authors
[47] Sinovoltaics, *Introduction to Solar Panel Recycling,* March 2014. Accessed October 2016. http://sinovoltaics.com/solar-basics/introduction-to-solar-panel-recycling/
[48] Brookhaven National Laboratory. Vasilis Fthenakis, *Regulations on Photovoltaic Module Disposal and Recycling.* January 29, 2001.
[49] Parikhit Sinha, et al. Evaluation of Potential Health and Environmental Impacts from End-Of-Life Disposal of Photovoltaics, Photovoltaics, 2014.
[50] First Solar. Parikhit Sinha, Andreas Wade. *Assessment of Leaching Tests for Evaluating Potential Environmental Impacts of PV Module Field Breakage.* October 2015. Accessed August 2016. http://www.firstsolar.com/-/media/Documents/Sustainability/PVSC42-Manuscript-20150912--Assessment-of-Leaching-Tests-for-Evaluating-Potential-Environmental-Impa.ashx
[51] First Solar. Dr. Yasunari Matsuno. December 2013. *Environmental Risk Assessment of CdTe PV Systems to be considered under Catastrophic Events in Japan.* http://www.firstsolar.com/-/media/Documents/Sustainability/Peer-Reviews/Japan_Peer-Review_Matsuno_CdTe-PV-Tsunami.ashx
[52] Phone interview, February 3, 2016, TT&E Iron & Metal, Garner, NC www.ncscrapmetal.com/
[53] Wen-His Huang, et al. *Strategy and Technology To Recycle Water-silicon Solar Modules.* Solar Energy, Volume 144, March 2017, Pages 22-31
[54] International Renewable Energy Agency. Stephanie Weckend, Andreas Wade, Garvin Heath. *End of Life Management: Solar Photovoltaic Panels.* June 2016. Accessed November 2016. http://www.irena.org/DocumentDownloads/Publications/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf
[55] Official Journal of the European Union. *Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on Waste Electrical and Electronic Equipment.* July 2012. Accessed November 2016. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0019
[56] PV CYCLE. *Annual Report 2015.* Accessed November 2016. https://pvcyclepublications.cld.bz/Annual-Report-PV-CYCLE-2015/6-7
[57] Official Journal of the European Union. *Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on Waste Electrical and Electronic Equipment.* July 2012. Accessed November 2016. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0019
[58] SEIA National PV Recycling Program: www.seia.org/seia-national-pv-recycling-program
[59] RBI Solar, Decommissioning Plan submitted to Catawba County associated with permitting of a 5MW solar project in June 2016. Accessed April 2017. www.catawbacountync.gov/Planning/Projects/Rezonings/RZ2015-05_DecommissioningPlan.pdf
[60] Birdseye Renewables, Decommissioning Plan submitted to Catawba County associated with permitting of a 5MW solar project in May 2015. Accessed April 2017. www.catawbacountync.gov/Planning/Projects/Rezonings/RZ2015-04_DecommissioningPlan.pdf
[61] Cypress Creek Renewables, Decommissioning Plan submitted to Catawba County associated with permitting of a 5MW solar project in September 2016. Accessed April 2017. www.catawbacountync.gov/Planning/Projects/Rezonings/RZ2016-06decommission.pdf
[62] Sun Raised Farms: http://sunraisedfarms.com/index.html
[63] National Institute of Environmental Health Sciences and National Institutes of Health, EMF: Electric and Magnetic Fields Associated with Electric Power: Questions and Answers, June 2002

[64] World Health Organization. *Electromagnetic Fields and Public Health: Exposure to Extremely Low Frequency Fields*. June 2007. Accessed August 2016. http://www.who.int/peh-emf/publications/facts/fs322/en/
[65] Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems, National Research Council, Possible Health Effects of Exposure to Residential Electric and Magnetic Fields, ISBN: 0-309-55671-6, 384 pages, 6 x 9, (1997) This PDF is available from the National Academies Press at: http://www.nap.edu/catalog/5155.html
[66] World Health Organization. *Electromagnetic Fields and Public Health: Exposure to Extremely Low Frequency Fields*. June 2007. Accessed August 2016. http://www.who.int/peh-emf/publications/facts/fs322/en/
[67] World Health Organization. *Electromagnetic Fields and Public Health: Static Electric and Magnetic Fields*. March 2006. Accessed August 2016. http://www.who.int/peh-emf/publications/facts/fs299/en/
[68] Asher Sheppard, Health Issues Related to the Static and Power-Frequency Electric and Magnetic Fields (EMFs) of the Soitec Solar Energy Farms, April 30, 2014. Accessed March 2017: www.sandiegocounty.gov/content/dam/sdc/pds/ceqa/Soitec-Documents/Final-EIR-Files/Appendix_9.0-1_EMF.pdf
[69] Massachusetts Clean Energy Center. *Study of Acoustic and EMF Levels from Solar Photovoltaic Projects*. December 2012. Accessed August 2016.
[70] Duke Energy Corporation. *Frequently Asked Questions: Electric and Magnetic Fields*. Accessed August 2016. https://www.duke-energy.com/about-energy/frequently_asked_questions.asp
[71] National Institute of Environmental Health Sciences, *Electric and Magnetic Fields Associate with the use of Electric Power: Questions and Answers*, 2002. Accessed November 2016 www.niehs.nih.gov/health/materials/electric_and_magnetic_fields
[72] Duke Energy Corporation. *Frequently Asked Questions: Electric and Magnetic Fields*. Accessed August 2016. https://www.duke-energy.com/about-energy/frequently_asked_questions.asp
[73] R.A. Tell et al, *Electromagnetic Fields Associated with Commercial Solar Photovoltaic Electric Power Generating Facilities*, Journal of Occupational and Environmental Hygiene, Volume 12, 2015,- Issue 11. Abstract Accessed March 2016: http://www.tandfonline.com/doi/full/10.1080/15459624.2015.1047021
[74] Massachusetts Department of Energy Resources, Massachusetts Department of Environmental Protection, and Massachusetts Clean Energy Center. *Questions & Answers: Ground-Mounted Solar Photovoltaic Systems*. June 2015. Accessed August 2016. http://www.mass.gov/eea/docs/doer/renewables/solar/solar-pv-guide.pdf
[75] Ibid.
[76] Ibid.
[77] *EMFs and medical devices*, Accessed March 2017. www.emfs.info/effects/medical-devices/
[78] ibid.
[79] Damon McCluer. *Electrical Construction & Maintenance: NFPA 70E's Approach to Considering DC Hazards*. September 2013. Accessed October 2016. http://ecmweb.com/safety/nfpa-70e-s-approach-considering-dc-hazards,
[80] Hong-Yun Yang, et. al. *Experimental Studies on the Flammability and Fire Hazards of Photovoltaic Modules, Materials*. July 2015. Accessed August 2016. http://www.mdpi.com/1996-1944/8/7/4210/pdf
[81] Matt Fountain. The Tribune. *Fire breaks out at Topaz Solar Farm*. July 2015. Accessed August 2016. www.sanluisobispo.com/news/local/article39055539.html
[82] Cooperative Research Network. Matthew Paiss. *Tech Surveillance: PV Safety & Code Developments*. October 2014. Accessed August 2016. http://www.nreca.coop/wp-content/uploads/2013/06/ts_pv_fire_safety_oct_2014.pdf

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Health and Safety Concerns of Photovoltaic Solar Panels

Introduction

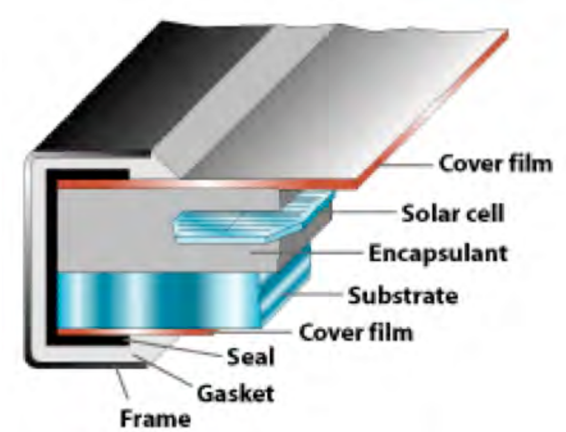
The generation of electricity from photovoltaic (PV) solar panels is safe and effective. Because PV systems do not burn fossil fuels they do not produce the toxic air or greenhouse gas emissions associated with conventional fossil fuel fired generation technologies. According to the U.S. Department of Energy, few power-generating technologies have as little environmental impact as photovoltaic solar panels.[1]

However, as with all energy sources, there are *potential* environmental, health and safety hazards associated with the full product life cycle of photovoltaics. Recent news accounts have raised public interest and concerns about those potential hazards.[2] A substantial body of research has investigated the life cycle impacts of photovoltaics including raw material production, manufacture, use and disposal. While some potentially hazardous materials are utilized in the life cycle of photovoltaic systems, none present a risk different or greater than the risks found routinely in modern society.

The most significant environmental, health and safety hazards are associated with the use of hazardous chemicals in the manufacturing phase of the solar cell. Improper disposal of solar panels at the end of their useful life also presents an environmental, health and safety concern. The extraction of raw material inputs, especially the mining of crystalline silica, can also pose an environmental, health and safety
The environmental, health and safety concerns for the life-cycle phase are minimal and limited to rare and infrequent events. With effective regulation, enforcement, and vigilance by manufacturers and operators, any danger to workers, the public and the environment can be minimized. Further, the benefits of photovoltaics tend to far outweigh risks especially when compared to conventional fossil fuel technologies. According to researchers at the Brookhaven National Laboratory, regardless of the specific technology, photovoltaics generate significantly fewer harmful air emissions (at least 89%) per kilowatt-hour (KWh) than conventional fossil fuel fired technologies.[3]

Materials used in photovoltaics solar panels

The basic building block of a photovoltaic solar system is the solar cell. Solar cells are solid state, semiconductor devices that convert sunlight into electricity. Typically a number of individual cells are connected together to form modules, or solar panels. In order to provide electrical insulation and protect against environmental corrosion, the solar cells are encased in a transparent material referred to as an encapsulant. To provide structural integrity the solar cells are mounted on top of a rigid flat surface or substrate. A transparent cover film, commonly glass, further protects these components from the elements.



Courtesy of the U.S. Department of Energy

Several types of semiconductor materials are used to manufacture solar cells but the most common material is crystalline silicon, typically from quartz or sand, capturing a 60% market share.[4] Crystalline silicon semiconductors are also utilized in the manufacture of integrated circuits and microchips used in personal computers, cellular telephones and other modern electronics.

The outer glass cover constitutes the largest share of the total mass of a finished crystalline photovoltaic module (approximately 65%), followed by the aluminum frame (~20%), the ethylene vinyl acetate encapsulant (~7.5%), the polyvinyl fluoride substrate (~2.5%), and the junction box (1%). The solar cells themselves only represent about four percent (4%) of the mass of a finished module.[5]

Oregon Department of Transportation Solar Highway photovoltaic solar panel selection
The solar panels proposed for use in the Oregon Department of Transportation's Solar Highway program feature domestically manufactured and assembled monocrystalline silicon modules. The information presented below, therefore, focuses on the life cycle environmental, health and safety hazards generally associated with this technology.

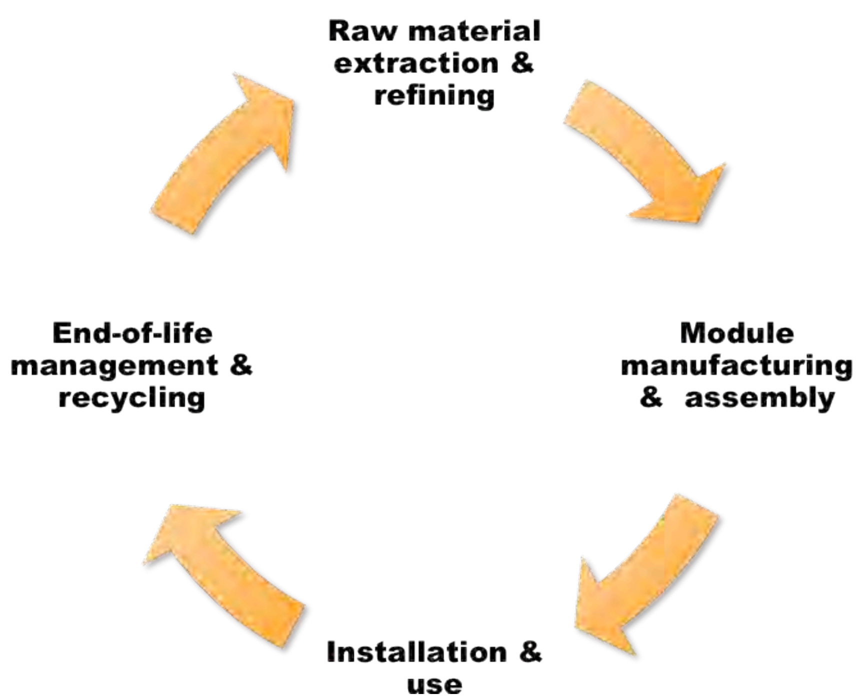
Life Cycle of Monocrystalline Silicon Solar Panels

The simplified process diagram below illustrates the basic life-cycle stages for the manufacturing of monocrystalline silicon (c-Si) solar panels.

The life cycle of a c-Si panel starts with mining of crystalline silica in the form of quartz or sand. The raw material is then refined in industrial furnaces to remove impurities to produce metallurgical grade silicon (~98% pure silicon). The metallurgical grade silicon is then further refined to produce high purity polysilicon for use in the solar and semiconductor industry. Next, the polysilicon is used to grow monocrystalline rods or ingots. These ingots are then shaped and sawn into very thin wafers. The wafers are then manufactured into solar cells and assembled into photovoltaic modules ready for installation. At the end of their useful life the materials in the panels can recycled and used as feedstock material for new panels.

The potential environmental, health and safety hazards associated with each of these steps are described on the following pages.

Figure 1: Simplified Photovoltaic Solar Panel Life Cycle



Raw material extraction and refining for solar panels

The material inputs phase consists of the extraction and processing of raw materials that are then used in the production of solar panels.

Crystalline Silica Mining

Process

Crystalline silica is the primary raw material input for the manufacture of monocrystalline solar panels. Crystalline silica is found in the environment primarily as sand or quartz. The extraction process varies by location, but typically involves some combination of earth moving, crushing, milling, washing, and screening to separate the crystalline silica particles from other minerals and impurities and to achieve the desired grain size.[6] The end product is variously referred to as silica sand, quartz silica or simply silica or quartz.

Health and Safety

A potentially harmful by-product associated with the mining and processing of silica sand is crystalline silica dust. Silica dust has been associated with silicosis, a lung disease where scar tissue forms in the lungs and reduces the ability to breath.[7] Crystalline silica dust is classified as a known human carcinogen by the International Agency for Research on Cancer.[8] Studies show increased risk of developing lung cancer through regular exposure to crystalline silica dust. Other health problems associated with regular, high exposure include chronic obstructive pulmonary disease, rheumatoid arthritis, scleroderma, Sjogern's syndrome, lupus, and renal disease.[9]

The widely recognized risk of human exposure to silica dust has resulted in the implementation of stringent health, safety, and environmental measures in the United States and across the globe. Examples of mitigation measures include monitoring air quality, automation of processes to limit human exposure, dust suppression measures and personal protective devices for workers such as respirators.[10]

It should be noted that the majority of global silica sand production (more than 80%) is used for the manufacture of glass and ceramics, metal casting and abrasives, while only 2% is utilized in the production of metallurgical grade silicon.[11]

Upgrading Silica Sand to Metallurgical Grade Silicon

Process

Metallurgical grade silicon is used in the manufacture of metal alloys such as aluminum and steel, chemical silicones for use in lubricants and epoxies as well as high purity polysilicon for the manufacture of semiconductors including solar panels. Consumption by the semiconductor industry, including photovoltaics, accounts for approximately 6% of global metallurgical grade silicon production.[12] In order to transform industrial grade silica sand into metallurgical grade silicon, the silica is combined with carbon in the form of charcoal, coal, or coke in an electric arc furnace in a process called carbothermic reduction.

Health and Safety

The primary emissions from this process are carbon dioxide and sulfur dioxide from the combustion of carbon sources. Another by-product of the process is fume silica captured via a piece of emission control technology called a bag house. If respirated, fume silica can pose the same health concerns as silica dust.[13] Additionally, there are indirect emissions of carbon dioxide from the consumption of electricity to power the electric arc furnace. The source and carbon intensity of this electricity varies by region.

Upgrading Metallurgical Grade Silicon to Polysilicon

Process

In order to reach a purity level acceptable for use in manufacture of semiconductor devices, metallurgical grade silicon must go through two additional purification steps. The primary output from this purification process is polysilicon, the precursor to the silicon wafers used to manufacture the integrated circuits at the heart of most electronics as well as monocrystalline photovoltaic solar cells.

In the first step, pulverized metallurgical grade silicon is combined with hydrogen chloride gas and a copper catalyst in a fluid bed reactor to produce trichlorosilane. Trichlorosilane is the primary chemical feedstock for the production of polysilicon. This step also yields silicon tetrachloride, which can either be captured and further processed into trichlorosilane or utilized as a feedstock in the manufacture of fiber optics. Other byproducts from this phase include silane, dichlorosilane and chlorinated metals. Dichlorosilane is an important precursor to silicon nitride, a ceramic material used, among other applications, in the manufacture of automobile engine parts.[14,15]

To produce polysilicon, the trichlorosilane is subjected to a distillation process until the desired purity level is achieved. The purified trichlorosilane is then used to deposit very pure polysilicon in a chemical vapor deposition reactor. This process, commonly referred to as the Siemens process, accounts for as much as 98% of the world's polysilicon production.[16] Historically, polysilicon destined for photovoltaic solar cells was considered "waste" material that did not meet the purity requirement of the electronics industry and accounted for approximately 10% of polysilicon production.[17] There are indications that this trend may be changing as the size of photovoltaic markets expand.

Health and Safety

This process involves multiple potentially hazardous materials and byproducts that without proper safeguards can pose a significant risk to human and environmental health. Chlorosilanes and hydrogen chloride are toxic and highly volatile, reacting explosively with water. Chlorosilanes and silane can also spontaneously ignite and under some conditions explode.[18] Silicon tetrachloride can cause skin burns and is also an eye and respiratory irritant.[19] Silicon tetrachloride has recently gained notoriety due to news accounts of its dumping near a polysilicon plant in China.[20]

Notably, Western production facilities accounted for more 99% of global polysilicon production in 2005, the latest year for which data is available.[21] These facilities use a closed loop process that captures system byproducts for recycling and reuse within the process loop because these recovery systems are necessary for the economic operation of a facility.[22] Furthermore, any waste gasses not recoverable for recycling are led through a series of pollution control technologies (e.g. wet scrubbers) prior to any environmental releases. Environmental releases include very low levels of particulate matter, hydrogen chloride and silicon tetrachloride.[23]

Furthermore, facilities in the United States, Japan and Europe are subject to strict environmental and occupational health and safety regulation and enforcement. In contrast, production capacity is rapidly expanding in developing countries such as China and India where such safeguards may not exist or be enforced. Regardless of their location, reputable and responsible firms will have implemented beyond compliance environmental management systems (e.g. ISO 14001 certification) and adopted voluntary industry best management guidelines (e.g. Responsible Care).

Manufacturing and assembly of solar panels

From Wafer to Cell

Process

Solar cells are produced by transforming polysilicon into a cylindrical ingot of monocrystalline silicon, which is then shaped and sliced into very thin wafers. Next, a textured pattern is imparted to the surface of the wafer in order to optimize the absorption of light. The wafer is then subjected to high temperatures in the presence of phosphorous oxychloride in order to create the physical properties required to produce electricity. Next an anti-reflective coating of silicon nitride is applied to the top surface of the cell to minimize reflection and increase efficiency of light absorption. Finally, metallic electrical conductors are screen printed onto the surface wafer to facilitate the transport of electricity away from the cell. The production of solar cells is concentrated in Japan, Europe and the United States, which currently account for more than 80% of global production.[24]

Health and Safety

Many different potentially hazardous chemicals are used during the production of solar cells. The primary environmental, health and safety concerns are exposure to and inhalation of kerf dust, a byproduct of sawing the silicon ingots into wafers, and exposure to solvents, such as nitric acid, sodium hydroxide and hydrofluoric acid, used in wafer etching and cleaning as well as reactor cleaning. Many of these solvents also pose a risk of chemical burns. Other occupational hazards include the flammability of silane used in the deposition of anti-reflective coatings.[25]

The most likely exposure route for factory workers is inhalation of vapors or dusts. Secondarily, there is exposure risk for factory workers from accidental spills. Risks to surrounding communities include the release of hazardous gasses from an industrial accident or fire at the manufacturing facility.[26] These hazards are regulated by a number of occupational and environmental standards as well as industry adopted voluntary best management practices. These regulations and strategies include: extensive occupational ventilation systems, accident prevention and planning programs and emergency confinement and absorption units.[27] As a result of these safeguards, there have been no known catastrophic releases of toxic gases from photovoltaic manufacturing facilities in the United States.[28]

Module components and assembly

Process

A typical solar module consists of several individual cells wired together and enclosed in protective material called an encapsulant, commonly made of ethylene vinyl acetate. To provide structural integrity the encapsulated cells are mounted on a substrate frequently made of polyvinyl fluoride. Both ethylene vinyl acetate and polyvinyl fluoride are widely considered to be environmentally preferable to other chlorinated plastic resins. A transparent cover, commonly glass, further protects these components from weather when in place for electrical generation. The entire module is held together in an aluminum frame. Most modules also feature an on board electrical junction box.[29]

Health and Safety

Individual solar cells are typically soldered together with copper wire coated with tin. Some solar panel manufacturers utilize solders that contain lead and other metals that if released into the environment can pose environmental and human health risks. Module assembly is not a likely pathway for human exposure to these metals as this step in the assembly process is typically automated. For more discussion regarding the end-of-life product phase risks of lead containing solders, see the discussion in the decommissioning and recycling section below.

Installation and use of solar panels

Installed silicon-based cells pose minimal risks to human health or the environment according to reviews conducted by the Brookhaven National Lab and the Electric Power Research Institute.[30]

Health and Safety

Because solar panels are encased in heavy-duty glass or plastic, there is little risk that the small amounts of semiconductor material present can be released into the environment.

In the event of a fire, it is theoretically possible for hazardous fumes to be released and inhalation of these fumes could pose a risk to human health.[31] However, researchers do not generally believe these risks to be substantial given the short-duration of fires and the relatively high melting point of the materials present in the solar modules. [32] Moreover, the risk of fire at ground-mounted solar installations is remote because of the precautions taken during site preparation including the removal of fuels and the lack of burnable materials – mostly glass and aluminum – contained in a solar panel.

A greater potential risk associated with photovoltaic systems and fire is the potential for shock or electrocution if a fire-fighter or emergency responder comes in contact with a high voltage conductor. These concerns are almost entirely related to roof mounted residential and commercial solar arrays. The Oregon Building Code Division is currently considering new rules to increase public safety for structures equipped with solar photovoltaic systems. The proposed rules are inspired by a model code adopted by the California Department of Forestry & Fire Protection. As it applies to ground mounted photovoltaic arrays, the California model code calls for a clear marking of system components in order to provide emergency responders with appropriate warnings.[33]

The strength of electromagnetic fields produced by photovoltaic systems do not approach levels considered harmful to human health established by the International Commission on Non-Ionizing Radiation Protection. Moreover the small electromagnetic fields produced by photovoltaic systems rapidly diminish with distance and would be indistinguishable from normal background levels within several yards. For a detailed discussion of electromagnetic fields and solar arrays read the *Scaling Public Concerns of Electromagnetic Fields Produced by Solar Photovoltaic Arrays* paper at http://www.oregonsolarhighway.com.

End-of-life management and recycling of solar panels

Process

While the solar cell is the heart of a photovoltaic system, on a mass basis it accounts for only a small fraction of the total materials required to produce a solar panel. The outer glass cover constitutes the largest share of the total mass of a finished crystalline photovoltaic module (approximately 65%), followed by the aluminum frame (~20%), the ethylene vinyl acetate encapsulant (~7.5%), the polyvinyl fluoride substrate (~2.5%), and the junction box (1%). The solar cells themselves only represent about four percent (4%) of the mass of a finished module.[34]

Proper decommissioning and recycling of solar panels both ensures that potentially harmful materials are not released into the environment and reduces the need for virgin raw materials. In recognition of these facts, the photovoltaic industry is acting voluntarily to implement product take-back and recycling programs at the manufacturing level. Collectively, the industry recently launched PV Cycle – a trade association to develop an industry-wide take back program in Europe.[35] In the United States, product take-back and recycling programs vary by manufacturer; SolarWorld, the supplier selected for the three Oregon Solar Highway projects, is one of the manufacturers which fully supports the entire life cycle of their product.

While recycling methods and take-back policies vary by manufacturer, the most frequently recycled components are the cover glass, aluminum frame, and solar cells. Small quantities of valuable metals including copper and steel are also recoverable. The ethylene vinyl acetate encapsulant and polyvinyl fluoride substrate are typically not recoverable and are removed through a thermal process with strict emission controls and the by-product ash land-filled. Following this process, the glass and aluminum frame are separated and typically sold to industrial recyclers. The solar cells are then reprocessed into silicon wafers with valuable metals recovered and sold. Depending on the condition, the wafer can then either be remade into a functioning cell or granulated to serve as feedstock for new polysilicon.[36]

Health and Safety

If not properly decommissioned, the greatest end of life health risk from crystalline solar modules arises from lead containing solders. Under the right conditions it is possible for the lead to leach into landfill soils and eventually into water bodies. Notably total lead solder use accounts for only approximately 0.5% of lead use in the United States.

References

[1] U.S. Dept. of Energy (2010). “Photovoltaic Basics.” Accessed January 5, 2010 at http://www1.eere.energy.gov/solar/pv_basics.html.

[2] Silicon Valley Toxics Coalition (2009). “Toward a Just and Sustainable Solar Energy Industry.” Available at http://www.svtc.org/site/DocServer/Silicon_Valley_Toxics_Coalition_-_Toward_a_Just_and_Sust.pdf?docID=821.

[3] Vasilis Fthenakis, Hyung Chul Kim and Erik Alsema (2008). "Emissions from Photovoltaic Life-Cycles." *Environmental Science and Technology* 2008 42 (6):2168-2174*.* Available at: http://pubs.acs.org/doi/full/10.1021/es071763q.

[4] Energy Information Agency (2008). "Solar Photovoltaic Cell/Module Manufacturing Activities 2007." U.S. Department of Energy. Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/solarreport/solarpv.pdf.

5 Knut Sander (2007). Study on the Development of a Take Back and Recovery System for Photovoltaic Products. Brussels: Belgium: PV Cycles. Available at: http://www.pvcycle.org/fileadmin/pvcycle_docs/documents/publications/Report_PVCycle_Download_En.pdf

[6] Angello, VN (2004). "The Silica Industry in the Republic of South Africa." Republic of South Africa Department of Minerals and Energy. Available at http://www.dme.gov.za/pdfs/minerals/R44 - update 2007.pdf.

[7] Abdiaziz Yassin, Francis Yebesi and Rex Tingle (2005). “Occupational Exposure to Crystalline Silica Dust in the United States: 1988–2003.” *Environmental Health Perspectives* 113(3):255-260. Available at http://ehp.niehs.nih.gov/members/2004/7384/7384.pdf.

[8] IARC (1987). *Silica and Some Silicates*. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, Vol. 42. Lyon, France: International Agency for Research on Cancer.

[9] Abdiaziz Yassin, Francis Yebesi and Rex Tingle (2005). “Occupational Exposure to Crystalline Silica Dust in the United States: 1988–2003.” *Environmental Health Perspectives* 113(3):255-260. Available at http://ehp.niehs.nih.gov/members/2004/7384/7384.pdf.

[10] MineEx Health and Safety Council of New Zealand (2008). "Guideline for the Control Dust and Associated Hazards in Surface Mine and Quarries." Available at: http://www.minex.org.nz/pdf/SUR_Dust_Mar08.pdf

[11] Williams, Eric (2000). "Global Production Chains and Sustainability: The Case of High-purity Silicon and its Applications in IT and Renewable Energy." Tokyo: United Nations University Institute of Advanced Studies. Available at http://www.it-environment.org/publications/QITS report.pdf.

[12] Williams, Eric (2000). "Global Production Chains and Sustainability: The Case of High-purity Silicon and its Applications in IT and Renewable Energy." Tokyo: United Nations University Institute of Advanced Studies. Available at http://www.it-environment.org/publications/QITS report.pdf.

[13] Williams, Eric (2000). "Global Production Chains and Sustainability: The Case of High-purity Silicon and its Applications in IT and Renewable Energy." Tokyo: United Nations University Institute of Advanced Studies. Available at http://www.it-environment.org/publications/QITS report.pdf.

[14] Hashim, Uda, Ehsan , Abang, and Ahmad Ibrahim (2007). "High Purity Polycrystalline Silicon Growth and Characterization." *Chiang Mai Journal of Science.* Vol. 34, No.1: 47-53. Available at http://www.science.cmu.ac.th/journal-science/341_HighUda.pdf

[15] Williams, Eric (2000). "Global Production Chains and Sustainability: The Case of High-purity Silicon and its Applications in IT and Renewable Energy." Tokyo: United Nations University Institute of Advanced Studies. Available at http://www.it-environment.org/publications/QITS report.pdf.

[16] Hashim, Uda, Ehsan , Abang, and Ahmad Ibrahim (2007). "High Purity Polycrystalline Silicon Growth and Characterization." *Chiang Mai Journal of Science.* Vol. 34, No.1: 47-53. Available at http://www.science.cmu.ac.th/journal-science/341_HighUda.pdf

[17] Y.S. Tsuo, T.H. Wang, and T.F. Ciszek (1999). Crystalline-Silicon Solar Cells for the 21st Century. Washington, D.C.: National Renewable Energy Lab.

[18] Vasilis Fthenakis. "National PV Environmental Research Center: Summary Review of Silane Ignition Studies." Available at http://www.bnl.gov/pv/abs/abs_149.asp.

[19] Adolf Goetzberger and Volker Hoffman (2005). "Photovoltaic Solar Energy Generation." *Springer*, New York.

[20] Ariana Eunjung Cha. "Solar Energy Firms Leave Waste Behind in China." *Washington Post*, March 9, 2009. Available at http://www.washingtonpost.com/wp-dyn/content/article/2008/03/08/AR2008030802595.html.

[21] Flynn, Hillary and Bradford, Travis (2006). Polysilicon: Supply, Demand & Implications for the PV Industry. Cambridge, MA: Prometheus Institute for Sustainable Development.

[22] Hashim, Uda, Ehsan , Abang, and Ahmad Ibrahim (2007). "High Purity Polycrystalline Silicon Growth and Characterization." *Chiang Mai Journal of Science.* Vol. 34, No.1: 47-53. Available at http://www.science.cmu.ac.th/journal-science/341_HighUda.pdf

[23] Hashim, Uda, Ehsan , Abang, and Ahmad Ibrahim (2007). "High Purity Polycrystalline Silicon Growth and Characterization." *Chiang Mai Journal of Science.* Vol. 34, No.1: 47-53. Available at http://www.science.cmu.ac.th/journal-science/341_HighUda.pdf

[24] Maycock, Paul and Bradford, Travis (2006). PV Technology, Performance and Cost. Cambridge, MA: Prometheus Institute for Sustainable Development.

[25] Fthenakis, V.M. (2003). Practical Handbook of Photovoltaics: Fundamentals and Applications: Overview of Potential Hazards. Available at http://www.bnl.gov/pv/files/pdf/art_170.pdf.

[26] Electric Power Research Institute (2003). "Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells." Report to the California Energy Commission, Palo Alto, CA. Available at http://mydocs.epri.com/docs/public/000000000001000095.pdf.

[27] Fthenakis, V.M. (2003). Practical Handbook of Photovoltaics: Fundamentals and Applications: Overview of Potential Hazards. Available at http://www.bnl.gov/pv/files/pdf/art_170.pdf.

[28] Electric Power Research Institute (2003). "Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells." Report to the California Energy Commission, Palo Alto, CA. Available at http://mydocs.epri.com/docs/public/000000000001000095.pdf.

[29] U.S. Dept. of Energy (2010). "Photovoltaic Basics." Accessed January 5, 2010 at http://www1.eere.energy.gov/solar/pv_basics.html.

[30] Electric Power Research Institute (2003). "Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells." Report to the California Energy Commission, Palo Alto, CA. Available at http://mydocs.epri.com/docs/public/000000000001000095.pdf.

[31] Union of Concerned Scientists (n/a). "Environmental Impacts of Renewable Energy Technologies." Available at http://www.ucsusa.org/clean_energy/technology_and_impacts/impacts/environmental-impacts-of.html.

[32] Electric Power Research Institute (2003). "Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells." Report to the California Energy Commission, Palo Alto, CA. Available at http://mydocs.epri.com/docs/public/000000000001000095.pdf.

[33] California Department of Forestry and Fire Prevention (2008). Solar Photovoltiac Installation Guidelines. Sacramento: CA. Available at: http://osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf

34 Knut Sander (2007). Study on the Development of a Take Back and Recovery System for Photovoltaic Products. Brussels: Belgium: PV Cycles. Available at: http://www.pvcycle.org/fileadmin/pvcycle_docs/documents/publications/Report_PVCycle_Download_En.pdf

[35] SolarWorld AG (2008). "Annual Group Report 2008 – With Integrated Sustainability Report SolarWorld AG." Available at http://www.solarworld.de/fileadmin/sites/solarworld/pdfs/financial-reports/ar2008.pdf.

36 Knut Sander (2007). Study on the Development of a Take Back and Recovery System for Photovoltaic Products. Brussels: Belgium: PV Cycles. Available at: http://www.pvcycle.org/fileadmin/pvcycle_docs/documents/publications/Report_PVCycle_Download_En.pdf

NOISE IMPACT ASSURANCE LETTER

March 12, 2021

C. Nils McKay, Planning Technician
Freetown Planning Board
Freetown Town Hall
3 North Main Street
Assonet, MA 02702

Re: Sound Attenuation Analysis
Middleboro Road Solar Project – Site Plan Review Application
32 Middleboro Road, Freetown, MA

Dear Members of the Planning Board:

This letter presents a Sound Attenuation Analysis of the proposed Middleboro Road Solar Project.

In general, according to a 2012 study commissioned by the Massachusetts Clean Energy Center, attached hereto as **Exhibit A**, sound from a solar array itself is negligible, and sound from typical inverters and transformers such as those used on this project, is inaudible at setback distances of 50 to 150 feet, depending on ambient noise. The study, which included actual sound measurements from a fully constructed and operating solar facility, showed that the audible sound level directly in front of a 500kW Inverter under full power decreases from a high of 73dBA at 10 feet away to a low of 43dBA, 150 feet away. At 43dBA, the noise emitted by the inverter equipment is comparable to the noise level in a quiet office or living room. Beyond 150 feet, the inverter is inaudible.

Specific to the Middleboro Road Solar Project, we have performed an analysis of the sound generated by the battery storage/central inverter, transformer and string inverters proposed at the Site to demonstrate that any sound emissions from these components will be diminished over the long distance to abutting properties.

The Middleboro Road Solar Project proposes to use a 750 kVA liquid-immersed three-phase distribution transformer, a Sungrow SG125HV String Inverter and Sungrow ST556KWH Series Lithium-Ion Battery/Centralized Inverter, which emit approximately 57 dB, 60 dB and 70 dB respectively while in operation. A copy of the Sungrow Noise Level Test Report for the inverter and battery components can be found attached as **Exhibit B** while the NEMA Standards Publication R2000 for Transformers, Regulators and Reactors can be found attached as **Exhibit C**. The audible noise level produced by the transformer, battery, string inverter or similar device over a given distance can be estimated using the following industrial standard equation:

$$L_2 = L_1 - \left|20 \times \log \frac{r_1}{r_2}\right| \qquad \textit{Eq. 1.0}$$

Where r1 (ft) is the reference distance, r2 (ft) is the distance from the sound source, L1 is the sound (dB) at source (i.e. sound level at r1), and L2 is sound level (dB) at distance r2.

The proposed transformer produces 57 dB (L1) and will be installed approximately 395 feet (r2) from the closest residential abutting property line, 6 Clermont Way. The equation is filled-in as follows:

$$\begin{gathered} L_2 = 57 - \left|20 \times \log \frac{1}{395}\right| \qquad \textit{Eq. 1.1} \\ L_2 = 57 - |20 \times -2.59| \\ L_2 = 57 - |-51.9| \\ L_2 = 57 - 51.9 \\ L_2 \cong 5.1\ dB \end{gathered}$$

Per the above calculation, the sound level increase at the 6 Clermont Way property line generated by the transformer 395 feet away, is estimated to be 5.1 dB during operation (i.e. daytime hours). Per standard decibel level charts, 5.1 dB is equivalent to faint breathing.

The proposed project string inverter produces 60 dB (L1) and the one closest to a residential property is approximately 135 feet (r2) from the 6 Clermont Way property line. The equation is filled-in as follows:

$$\begin{gathered} L_2 = 60 - \left|20 \times \log \frac{1}{135}\right| \qquad \textit{Eq. 1.1} \\ L_2 = 60 - |20 \times -2.13| \\ L_2 = 60 - |-42.60| \\ L_2 = 60 - 42.60 \\ L_2 \cong 17.4\ dB \end{gathered}$$

Per the above calculation, sound level increase from the closest string inverter at the 6 Clermont Way property line is estimated to be 17.4 dB during operation (i.e. daytime hours). Per standard decibel level charts, 17.4 dB is equivalent to a whisper.

The proposed battery/central inverter module produces 70 dB (L1) and is located approximately 395 feet (r2) from the closest residential abutter, 9 Pinewood Court. The equation is filled-in as follows:

$$L_2 = 70 - \left|20 \times \log \frac{1}{395}\right| \qquad \textit{Eq. 1.1}$$

$$L_2 = 70 - |20 \times -2.59|$$

$$L_2 = 70 - |-51.93|$$

$$L_2 = 70 - 51.93$$

$$L_2 \cong 18.0dB$$

Per the above calculation, the sound level increase from the battery/central inverter at the 9 Pinewood Court property line is estimated to be 18.0 dB during operation (i.e. daytime hours). Per standard decibel level charts, 18.00 dB is equivalent to a whisper.

In practice, the sound will often be reflected or redirected by trees and terrain, reducing the level even further. Therefore, in our opinion, the calculated values for these components are reflective of an ideal/controlled environment for acoustic transmission.

Also, for comparison, the typical refrigerator produces 40 dB while in operation and 10 dB is normal breathing. Accordingly, we can estimate the sound produced by the proposed array will be negligible at abutting residential properties and, in our opinion, will have no negative audio impact at the abutting residential properties.

If you have any questions, please feel free to contact us at (508) 888-9282.

Very truly yours,

ATLANTIC DESIGN ENGINEERS, INC.

Richard J. Tabaczynski, P.E.
Vice President

cc: CVE North America, Inc.

Exhibit A

Study of Acoustic and EMF Levels from Solar Photovoltaic Projects
Massachusetts Clean Energy Center
2012

STUDY OF ACOUSTIC AND EMF LEVELS FROM SOLAR PHOTOVOLTAIC PROJECTS

Prepared for:
Massachusetts Clean Energy Center
9th Floor
55 Summer Street
Boston, MA 02110

Prepared by:
Tech Environmental, Inc.
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Waltham, MA 02451

STUDY OF ACOUSTIC AND EMF LEVELS FROM SOLAR PHOTOVOLTAIC PROJECTS

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December 17, 2012

ACKNOWLEDGEMENTS

The study team would like to thank the owners and managers of the four project sites for participating in this study and their cooperation in gaining access to the sites, operational data, and system specifications.

We would also like to thank Bram Claeys of the Massachusetts Department of Energy Resources as well as Elizabeth Kennedy and Peter McPhee of the Massachusetts Clean Energy Center for their thorough and insightful review of this study.

EXECUTIVE SUMMARY

Sound pressure level and electromagnetic field (EMF) measurements were made at three utility-scale sites with solar photovoltaic (PV) arrays with a capacity range of 1,000 to 3,500 kW (DC at STC) under a full-load condition (sunny skies and the sun at an approximate 40^{o} azimuth). Measurements were taken at set distances from the inverter pads and along the fenced boundary that encloses the PV array. Measurements were also made at set distances back from the fenced boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of equipment sound levels.

EMF measurements were also made at one residential PV installation with a capacity of 8.6 kW under a partial-load condition. PV array operation is related to the intensity of solar insolation. Less sunshine results in lower sound and EMF levels from the equipment, and no sound or EMF is produced at night when no power is produced. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

<u>Sound levels</u> along the fenced boundary of the PV arrays were generally at background levels, though a faint inverter hum could be heard at some locations. Any sound from the PV array and equipment was inaudible at set back distances of 50 to 150 feet from the boundary. Average L_{eq} sound levels at a distance of 10 feet from the inverter face varied over the range of 48 dBA to 61 dBA for Site 2 and Site 3 Inverters[1], and were higher in the range of 59 to 72 dBA for Site 1 Inverters. Along the axis perpendicular to the plane of the inverter face and at distances of 10 to 30 feet, sound levels were 4 to 13 dBA higher compared to levels at the same distance along the axis parallel to the inverter face. At 150 feet from the inverter pad, sound levels approached background levels. Sound level measurements generally followed the hemispherical wave spreading law (-6 dB per doubling of distance).

The time domain analysis reveals that 0.1-second L_{eq} sound levels at a distance of 10 feet from an inverter pad generally varied over a range of 2 to 6 dBA, and no recurring pattern in the rise and fall of the inverter sound levels with time was detected. The passage of clouds across the face of the sun caused cooling fans in the inverters to briefly turn off and sound levels to drop 4 dBA.

[1] The same make of inverters were used at Sites 2 and 3.

The 1/3-octave band frequency spectrum of inverter sound at the close distance of 10 feet shows energy peaks in several mid-frequency and high-frequency bands, depending on the inverter model. Tonal sound was found to occur in harmonic pairs: 63/125 Hz; 315/630 Hz; 3,150/6,300 Hz; and 5,000/10,000 Hz. The high frequency peaks produce the characteristic “ringing noise” or high-frequency buzz heard when one stands close to an operating inverter. The tonal sound was not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum. All low-frequency sound from the inverters below 40 Hz is inaudible, at all distances.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has a recommended electric field level exposure limit of 4,200 Volts/meter (V/m) for the general public. At the utility scale sites, electric field levels along the fenced PV array boundary, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels (< 5 V/m). Electric fields near the inverters were also not elevated above background levels (< 5 V/m). At the residential site, indoor electric fields in the rooms closest to the roof-mounted panels and at locations near the inverters were not elevated above background levels (< 5 V/m).

The International Commission on Non-Ionizing Radiation Protection has a recommended magnetic field level exposure limit of 833 milli-Gauss (mG) for the general public. At the utility scale sites, magnetic field levels along the fenced PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations 50 to 150 feet from the fenced array boundary were not elevated above background levels (<0.2 mG). There are significant magnetic fields at locations a few feet from these utility-scale inverters, in the range of 150 to 500 mG. At a distance of 150 feet from the inverters, these fields drop back to very low levels of 0.5 mG or less, and in many cases to background levels (<0.2 mG). The variation of magnetic field with distance generally shows the field strength is proportional to the inverse cube of the distance from equipment.

At the residential site, indoor magnetic field levels in the rooms closest to the roof-mounted panels were in the low range of 0.2 to 1.4 mG. There are low-level magnetic fields at locations a few feet from the inverters, in the range of 6 to 10 mG. At a distance of no more than 9 feet from the inverters, these fields dropped back to the background level at this residential site of 0.2 mG. Due to the relatively high background level in the residential site basement where the inverters were housed, the relationship of magnetic field strength to distance from the inverters could not be discerned.

TABLE OF CONTENTS

1.0 INTRODUCTION

The goal of this study is to conduct measurements at several ground-mounted PV arrays in Massachusetts to determine the sound pressure levels and electromagnetic field (EMF) levels generated by PV arrays and the equipment pads holding inverters and small transformers. This information will be used to inform local decision-makers and the public about the acoustic and EMF levels in the vicinity of PV projects.

Measurements were made at three utility-scale sites having PV arrays with a capacity range of 1,000 to 3,500 kW (DC at STC), with weather conditions consisting of sunny skies and the sun at approximately 40^{o} azimuth. Measurements were also made at one residential[2] PV installation with a capacity of 8.6 kW under a partial-load condition. Sound level and EMF data were collected at set distances from the inverter pads and along the fenced boundary of the PV array. Measurements were also made at set distances back from the fenced boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of equipment sound levels. Figure 1 shows a schematic map of a typical utility scale PV array containing four inverter pads and a fenced boundary. The orange stars show typical measurement locations around the fenced boundary of the array and at fixed set back distances of 50 feet, 100 feet, and 150 feet from the boundary. The green stars represent typical measurement locations at three set back distances from inverters on two of the equipment pads. At each equipment pad that was sampled, sound level measurements were made in two directions: along an axis parallel to the inverter face and along an axis perpendicular to the inverter face. Figure 2 illustrates a sound meter setup along the axis perpendicular to (90^{o} from) an inverter face.

Section 2.0 of this report describes the measurement methods and locations, while Section 3.0 presents the measurement results in detail for the four sites. Study conclusions are given in Section 4.0. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

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[2] Only EMF measurements were made at the residential site.

Figure 1. Schematic Map of Sound and EMF Measurement Locations at a Solar Photovoltaic (PV) Array

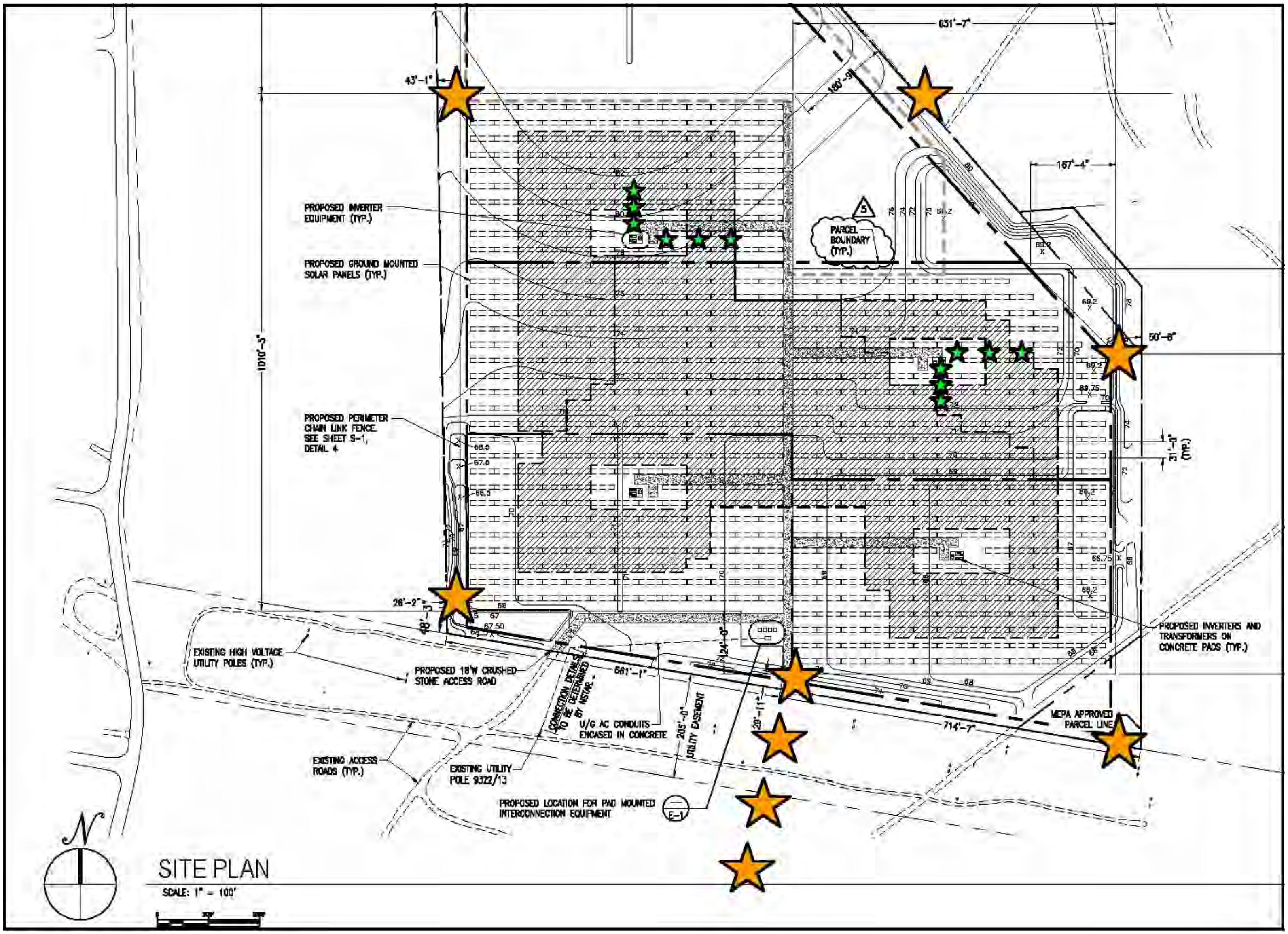

Figure 2. Sound Level Meter on the Axis Perpendicular to the Face of an Inverter at a Solar Photovoltaic (PV) Array

2.0 MEASUREMENT METHODS AND LOCATIONS

Sound pressure and EMF levels were measured along the fenced boundary of each PV array, at three set back distances from the boundary, and at fixed distances from equipment pads housing inverters and transformers (see Figures 1 and 2). Sound levels were measured with a tripod-mounted ANSI Type 1 sound meter, a Bruel & Kjaer Model 2250 meter, equipped with a large 7-inch ACO-Pacific WS7-80T 175 mm (7-inch) wind screen that is oversize and specially designed to screen out wind flow noise. An experimental study of wind-induced noise and windscreen attenuation effects by Hessler[3] found that the WS7-80T windscreen keeps wind-induced noise at the infrasound frequency band of 16 Hz to no more than 42 dB for moderate across-the–microphone wind speeds. That minimal level of wind-induced noise is 8 to 20 dB below the 16-Hz levels measured in this study.

The B&K Model 2250 measures 1/3-octave bands down to 6.3 Hz, well into the infrasonic range, and up to 20,000 Hz, the upper threshold of human hearing. The sound meter first recorded short-term (1-minute L_{eq} and L_{90}) broadband sound levels (in A-weighted decibels, dBA) at the established survey points. Then the sound meter was placed at the nearest measurement distance to each equipment pad to record a 10-minute time series of broadband and 1/3-octave band L_{eq} sound levels (in decibels, dB) at 0.1-second intervals. The L_{90} sound level removes intermittent noise and thus is lower than the L_{eq} sound level in the tables of results provided in Section 3.

EMF levels of both the magnetic field (in milliGauss, mG) and the electric field (in Volts/meter, V/m) were measured using a pair of Trifield Model 100XE EMF Meters. These instruments perform three-axis sampling simultaneously, enabling rapid survey of an area. The Trifield meters have a range for magnetic fields of 0.2 to 10,000 mG, and for electric fields from 5 to 1,000 V/m. EMF measurements were taken at the same survey points as the sound level measurements.

Measurements were made along the fenced boundary around each PV array at four to six evenly-spaced locations (depending on the size of the array), and at three additional locations set back 50 feet, 100 feet, and 150 feet from the boundary. At each equipment pad that was sampled, sound level

[3] Hessler, G., Hessler, D., Brandstatt, P., and Bay, K., "Experimental study to determine wind-induced noise and windscreen attenuation effects on microphone response for environmental wind turbine and other applications", Noise Control Eng. J., 56(4), 2008.

measurements were made in two directions: parallel to the inverter face, and perpendicular to the equipment face. The closest sound monitoring location was selected at a distance "1X" where the inverter or transformer sound was clearly audible above background levels. The closest EMF monitoring location was selected at a distance "1X" where magnetic field levels were approximately 500 mG, a level that is below the ICNIRP-recommended[4] human exposure limit of 833 mG (see Appendix B). Additional sampling points were then placed at distances[5] of 2X, 3X, and at 150 feet from the equipment pad, in the two orthogonal directions. There were a total of eight monitoring locations for each equipment pad, and seven to nine locations for the PV array boundary.

Measurements were made on October 11, 17, 22 and 26, 2012 around 12:30 p.m. EDT, the time of peak solar azimuth, and only on days for which clear skies were forecast to maximize solar insolation to the PV array. The peak solar azimuth in southern Massachusetts was approximately 40^o azimuth on these dates. Consistent with standard industry practice, background levels of sound and EMF were measured at representative sites outside the fenced boundary of the PV array and far enough away to not be influenced by it or any other significant nearby source. The background levels presented for each site were made at distances of 50 feet, 100 feet, and 150 feet from the fenced boundary around the PV array (see Figure 1).

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[4] International Commission on Non-Ionizing Radiation Protection.

[5] Location 2X is twice the distance from the equipment as location 1X; Location 3X is three times that distance.

3.0 MEASUREMENT RESULTS

Sound and EMF measurements were made at the following four PV arrays, presented in the following sections:

Site 1 – Achusnet ADM, Wareham, MA
Site 2 – Southborough Solar, Southborough, MA
Site 3 – Norfolk Solar, Norfolk, MA
Site 4 – Residential PV array owned by Massachusetts Audubon Society, Sharon, MA

3.1 Site 1 – Achusnet ADM

Facility Location:	27 Charlotte Furnace Road, Wareham, MA
Facility Owner:	Borrego Solar Systems, Inc.
System Capacity:	3,500 kW
Power Output During Monitoring:	3,500 kW
No. & Size Inverters:	(7) 500-kW inverters
Date Measured:	Thursday October 11, 2012
Cloud Cover:	0%
Winds:	West 10-12 mph
Ground:	Open area between cranberry bogs, no buildings or vegetation.
Background Sound:	Mean value L_{eq} of 46.4 dBA (range of 45.6 to 47.0 dBA). Mean value of L_{90} 43.9 dBA (range of 41.6 to 45.4 dBA). Sources included highway traffic on I-495 (to the south), earthmoving equipment to the east, birds and other natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m) except along southern boundary from hi-voltage power lines overhead, and near the eastern boundary from low-voltage power lines overhead.

The solar photovoltaic array is in a flat area between cranberry bogs east of Charlotte Furnace Road in Wareham and the boundary of the array is fenced. The surrounding area has no buildings or vegetation. There are four equipment pads within the PV array, each housing one or two inverters. Measurements were made at two equipment pads: 1) the Northwest Pad, which contains two inverters and a small transformer, and 2) the Northeast Pad, which has one inverter and a small transformer. The sound and EMF measurements made at Site 1 are summarized in Tables 1 through 3. Figures 3 and 4 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location

(1X) for the Northwest and Northeast Equipment Pads, while Figure 5 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

Sound Levels

Background sound levels varied over time and space across the site. Highway traffic noise was the primary background sound source and higher levels were measured for locations on the south side of the site closer to the highway. Variable background sound was also produced by trucking activity to the east of the PV array, where sand excavated during the PV array's construction and stored in large piles was being loaded with heavy equipment into dump trucks and hauled away. Background sound levels varied over a range of 6 dBA. Background mean value L_{eq} and L_{90} levels were 46.4 dBA and 43.9 dBA, respectively. The PV array was inaudible outside of the fenced boundary, and was also inaudible everywhere along the boundary except at the North East boundary location where a faint inverter hum could be heard. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the North West Pad (which holds two 500-kW inverters) were 68.6 to 72.7 dBA and at the same distance from the North East Pad (which holds only one 500-kW inverter) were lower at 59.8 to 66.0 dBA. Along the axis perpendicular to the inverter face measured sound levels were 4 to 6 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels generally declined with distance following the hemispherical wave spreading law (approximately -6 dB per doubling of distance) and at a distance of 150 feet all inverter sounds approached background sound levels. Due to the layout of the solar panels, the measurements made perpendicular to the inverter face and at a distance of 150 feet were blocked from a clear line of sight to the inverter pad by many rows of solar panels, which acted as sound barriers.

The time domain analysis presented in Figures 3 and 4 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 3 to 4 dBA at the North West Pad and 2 to 3 dBA at the North East Pad. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. The inverters registered full 500-kW capacity during both 10-minute monitoring periods.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 5) shows energy peaks in four 1/3-octave bands, which are most pronounced for the North West Pad: 315 Hz, 630 Hz, 3,150 Hz, and 6,300 Hz. The two higher frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak in each pair is a first-harmonic tone (6,300 Hz being twice the frequency of 3,150 Hz). The tonal sound exhibited by Figure 5 is not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 5. The dashed line in Figure 5 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum is smooth except for a broad peak around 800 Hz caused by distant highway traffic noise and a peak at 8,000 Hz that represents song birds.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the boundary, are not elevated above background levels (< 5 V/m). The one measurement at 5.0 V/m in Table 1 was caused by the field around a nearby low-voltage power line overhead. Electric fields near the inverters are also not elevated above background levels (< 5 V/m). The one measurement at 10.0 V/m in Table 3 was caused by the meter being close to the front face of a solar panel at the 150-foot set back distance.

Magnetic Fields

Magnetic field levels along the PV array boundary and 50 feet from the boundary were in the very low range of 0.2 to 0.3 mG, except at the southern end of the boundary that is close to overhead high-voltage power lines, owned by the local utility and not connected to the project, where levels of 0.7 to 3 mG were measured, caused by those hi-voltage power lines. Magnetic field levels at the location 100 feet from the boundary were elevated by a low-voltage power line overhead. At 150 feet from the boundary, the magnetic field is not elevated above background levels (<0.2 mG).

Table 3 reveals that there are significant magnetic fields at locations a few feet from inverters, around 500 mG. These levels drop back to 0.2 to 0.5 mG at distances of 150 feet from the inverters. The variation of magnetic field with distance shown in Table 3 generally shows the field strength is proportional to the inverse cube of the distance from equipment. Following that law, the magnetic field at 5 feet of 500 mG should decline to 0.02 mG (< 0.2 mG) at 150 feet. The measured levels of 0.1 to 0.5 mG at 150 feet listed in Table 3 are likely caused by small-scale magnetic fields setup around the PV cells and connecting cables near the sampling locations.

TABLE 1

SOUND AND EMF LEVELS MEASURED AT SITE 1
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	39.1	42.5	< 0.2	< 5
South West Boundary	43.6	44.7	1.8	< 5
South Center Boundary	44.8	48.1	3.0	< 5
South East Boundary	44.0	45.6	0.7	< 5
North East Boundary	42.2	43.9	< 0.2	< 5
North Center Boundary	43.4	44.3	0.3	< 5
Background Mean Values	43.9	46.4	< 0.2	< 5
Set back 50 feet from Boundary	41.6	47.0	0.2	< 5
Set back 100 feet from Boundary	45.4	46.7	0.4	5.0
Set back 150 feet from Boundary	44.7	45.6	< 0.2	< 5

TABLE 2

SOUND LEVELS MEASURED AT SITE 1
EQUIPMENT PADS

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
North West Pad / Parallel to Inverter Face / 10 feet	67.6	68.6
North West Pad / Parallel to Inverter Face / 20 feet	61.8	63.1
North West Pad / Parallel to Inverter Face / 30 feet	58.8	60.6
North West Pad / Parallel to Inverter Face / 150 feet	45.2	46.0
North West Pad / Perpendicular to Inverter Face / 10 feet	71.8	72.7
North West Pad / Perpendicular to Inverter Face / 20 feet	63.5	64.8
North West Pad / Perpendicular to Inverter Face / 30 feet	59.5	62.3
North West Pad / Perpendicular to Inverter Face / 150 feet	41.8	43.0
North East Pad / Parallel to Inverter Face / 10 feet	59.1	59.8
North East Pad / Parallel to Inverter Face / 20 feet	55.4	56.2
North East Pad / Parallel to Inverter Face / 30 feet	54.8	55.7
North East Pad / Parallel to Inverter Face / 150 feet	43.4	44.0
North East Pad / Perpendicular to Inverter Face / 10 feet	65.5	66.0
North East Pad / Perpendicular to Inverter Face / 20 feet	59.8	60.2
North East Pad / Perpendicular to Inverter Face / 30 feet	56.3	56.9
North East Pad / Perpendicular to Inverter Face / 150 feet	41.0	43.6

TABLE 3

EMF LEVELS MEASURED AT SITE 1
EQUIPMENT PADS

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
North West Pad / Parallel to Inverter Face / 5 feet 3 inches	500	< 5
North West Pad / Parallel to Inverter Face / 10 feet 6 inches	10.5	< 5
North West Pad / Parallel to Inverter Face / 15 feet 9 inches	2.75	< 5
North West Pad / Parallel to Inverter Face / 150 feet	0.2	< 5
North West Pad / Perpendicular to Inverter Face / 4 feet	500	< 5
North West Pad / Perpendicular to Inverter Face / 8 feet	200	< 5
North West Pad / Perpendicular to Inverter Face / 12 feet	6.5	< 5
North West Pad / Perpendicular to Inverter Face / 150 feet	0.5	< 5
North East Pad / Parallel to Inverter Face / 3 feet 10 inches	500	< 5
North East Pad / Parallel to Inverter Face / 7 feet 8 inches	30	< 5
North East Pad / Parallel to Inverter Face / 11 feet 10 inches	4.5	< 5
North East Pad / Parallel to Inverter Face / 150 feet	0.2	10.0
North East Pad / Perpendicular to Inverter Face / 7 feet 6 inches	500	< 5
North East Pad / Perpendicular to Inverter Face / 15 feet	10	< 5
North East Pad / Perpendicular to Inverter Face / 22 feet 6 inches	2.1	< 5
North East Pad / Perpendicular to Inverter Face / 150 feet	0.1	< 5

Figure 3. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1

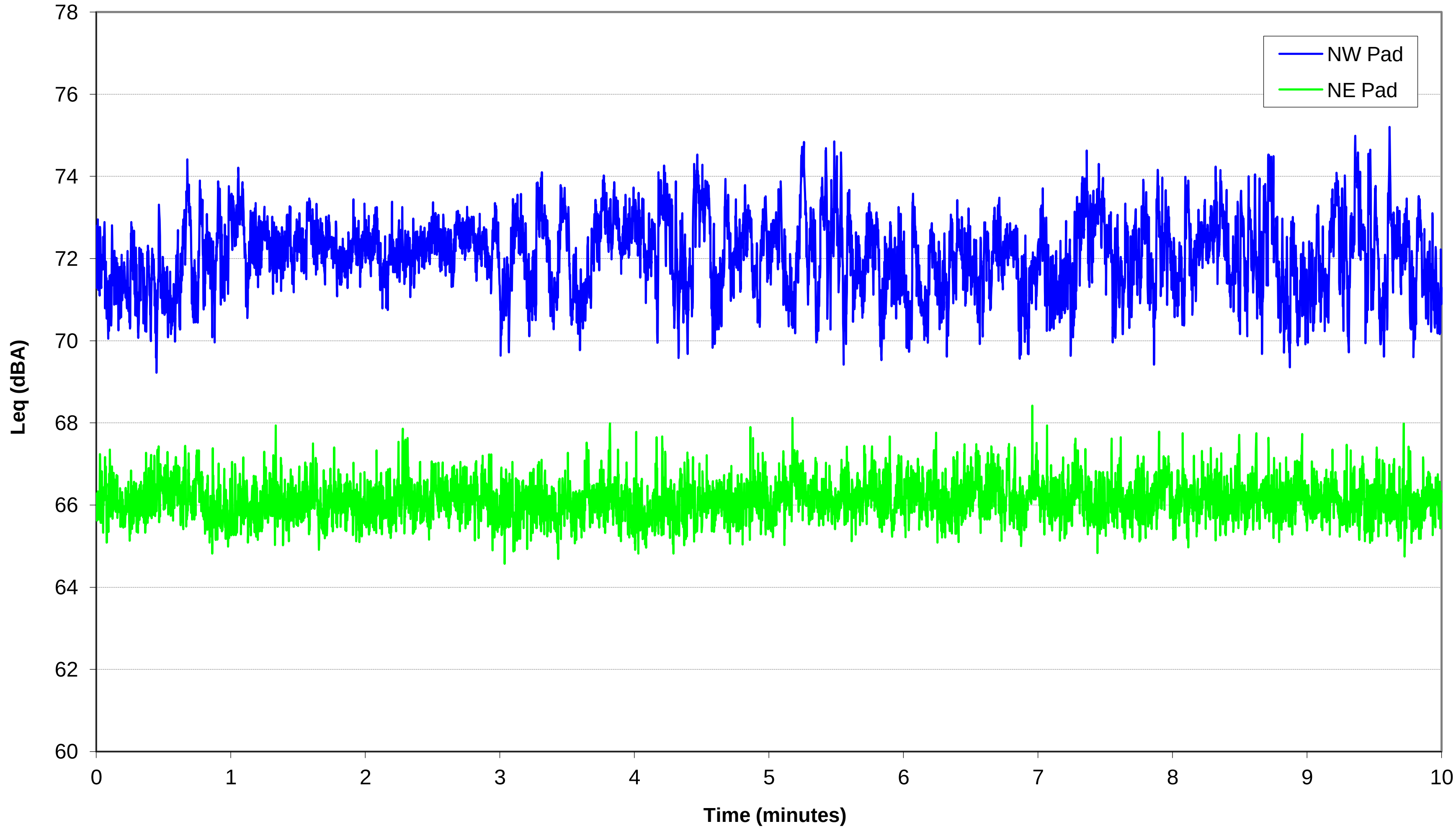


Figure 4. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1 - First 10 Seconds of Measurements

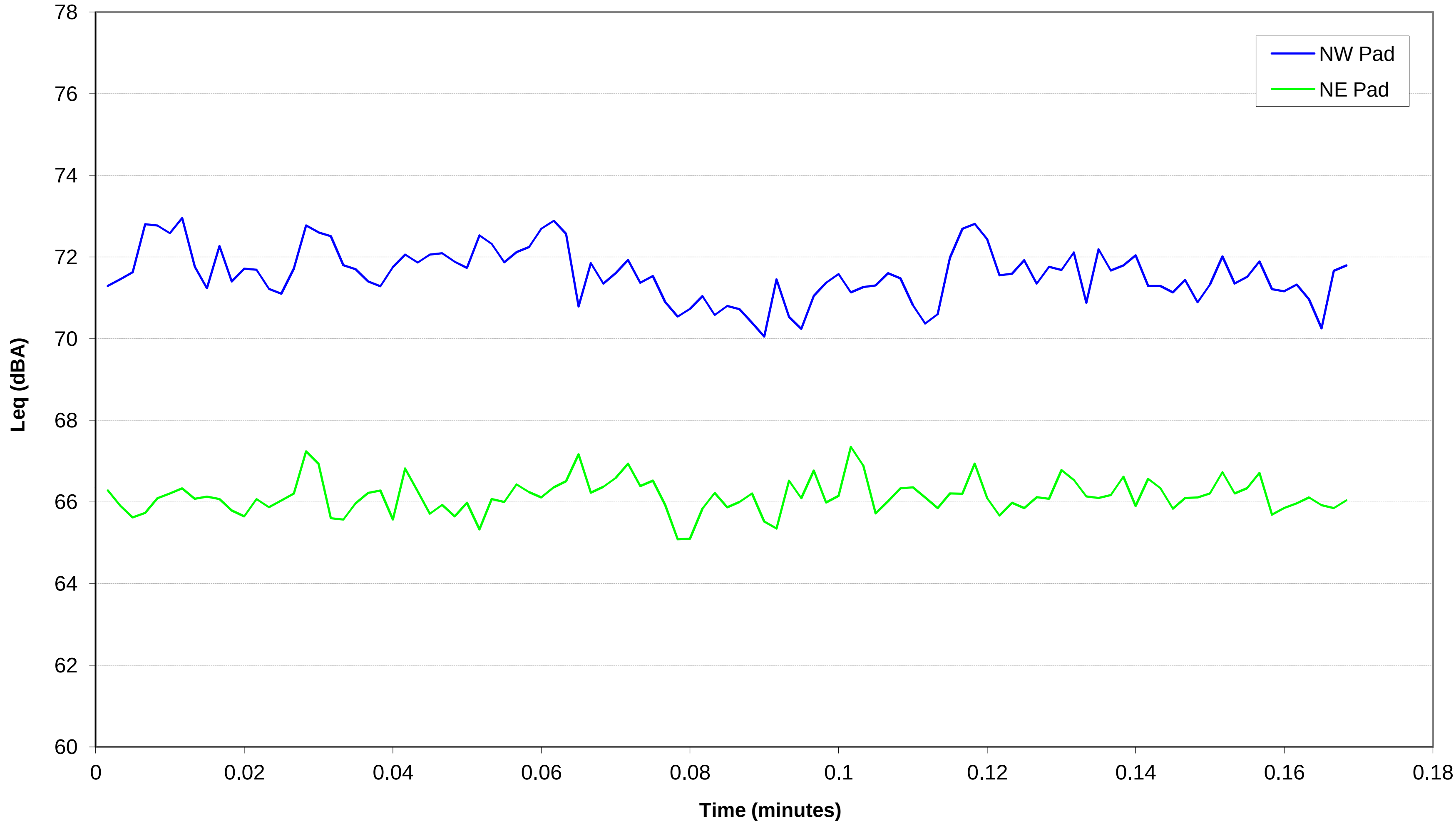
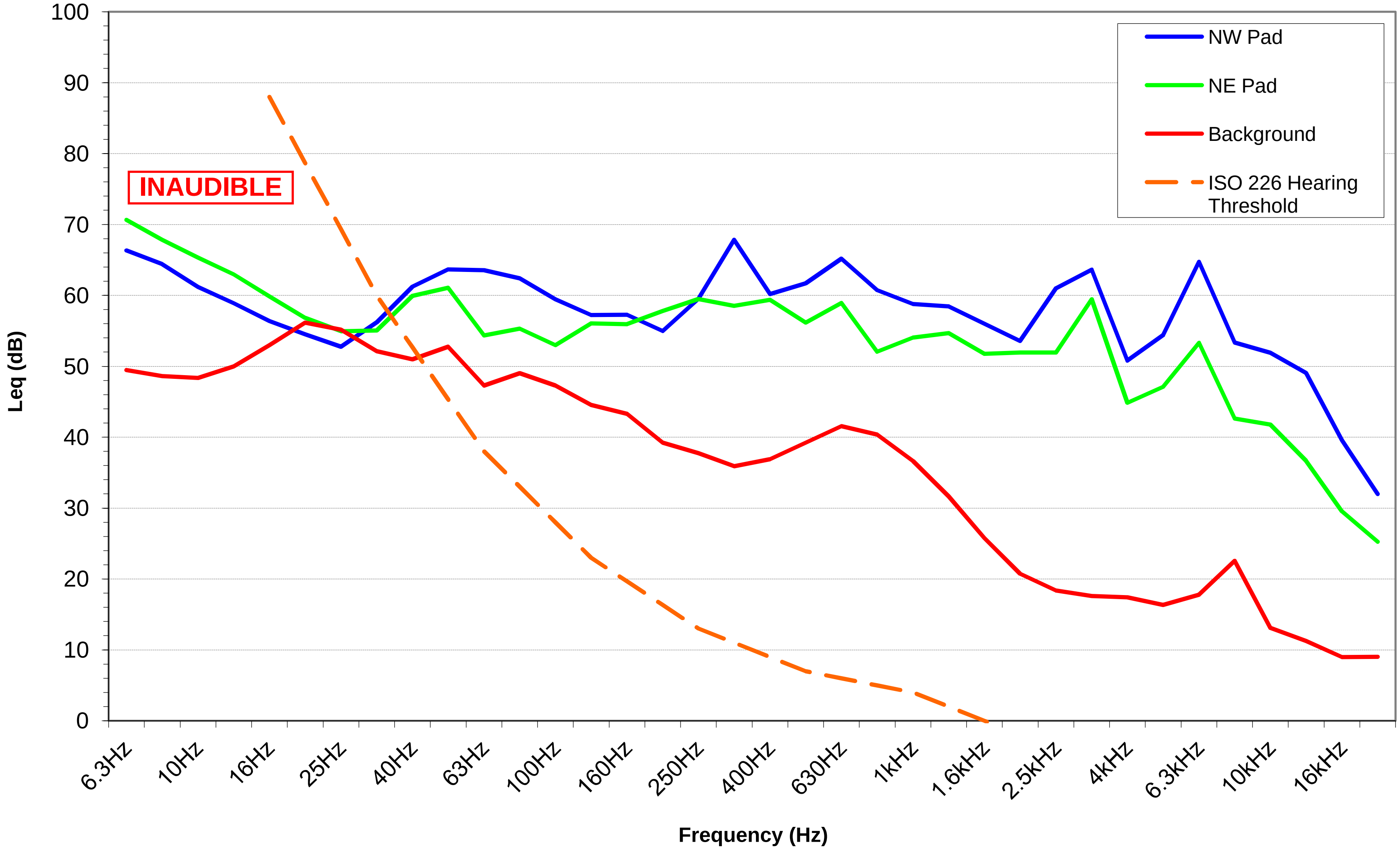


Figure 5. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1



3.2 Site 2 – Southborough Solar

Facility Location:	146 Cordaville Road, Southborough, MA
Facility Owner:	Southborough Solar, LLC
System Capacity:	1,000 kW
Power Output During Monitoring:	1,000 kW
No. & Size Inverters:	(2) 500-kW inverters
Date Measured:	Wednesday October 17, 2012
Cloud Cover:	5% (high, thin cirrus)
Winds:	Northwest 3-5 mph
Ground:	Wooded areas and wetlands surround the PV array, and a building is located to the south where the inverters are housed.
Background Sound:	Mean value L_{eq} of 53.1 dBA (range of 51.0 to 55.9 dBA). Mean value L_{90} of 49.6 dBA (range of 48.6 to 50.3 dBA). Sources included roadway traffic on Cordaville Road (to the west) and Route 9 (to the north) and natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m).

The solar photovoltaic array is in a cleared area of land east of Cordaville Road in Southborough and the boundary of the array is fenced. The array is surrounded by wetlands and woods. The two inverters are not within the PV array; instead they are located on a single pad at the southeast corner of the building that lies south of the PV array. Measurements were made at the one equipment pad housing the two inverters. Due to the close proximity of wetlands to the fenced boundary for the PV array, it was not possible to obtain measurements 50 to 150 feet from the boundary. Instead, measurements were taken 50 to 150 feet set back from the property boundary of the site near where the inverter pad is located. The sound and EMF measurements made at Site 2 are summarized in Tables 4 through 6. Figures 6 and 7 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location (1X) for the equipment pad, while Figure 8 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

<u>Sound Levels</u>

Background sound levels varied over time and space across the site, depending on the distance from Cordaville Road, which carries heavy traffic volumes. Roadway traffic noise was the primary background sound source and higher levels were measured for locations on the west side of the site closer to Cordaville Road. Background sound levels varied over a range of 5 to 7 dBA. The background mean value L_{eq} and L_{90} levels were 53.1 dBA and 49.6 dBA, respectively. The inverters were inaudible at a distance of 50 feet outside of the site boundary. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the equipment pad (which holds two 500-kW inverters) were 48.1 to 60.8 dBA. Along the axis perpendicular to the inverter face, measured sound levels were 10 to 13 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels did not follow the expected hemispherical wave spreading law (approximately -6 dB per doubling of distance) and declined at a lower rate with increasing distance due to the relatively high background sound levels from nearby roadway traffic. At a distance of 150 feet, all inverter sounds were below background sound levels.

The time domain analysis presented in Figures 6 and 7 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 5 to 6 dBA. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. The rise and fall in inverter sound levels over several minutes is thought to be due to the passage of sheets of high thin cirrus clouds across the face of the sun during the measurements. The inverters registered full 500-kW capacity during both 10-minute monitoring periods.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 8) shows energy peaks in two 1/3-octave bands: 5,000 and 10,000 Hz. These high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak is a first-harmonic tone (10 kHz being twice the frequency of 5 kHz). The tonal sound exhibited by Figure 8 is not, however, audible at distances of 50 to 150 feet beyond the site boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 8. The dashed line in Figure 8 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum declines smoothly with increasing frequency in the audible range except for a rise around 800 to 2,000 Hz caused by nearby roadway traffic noise.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the site boundary, are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels along the PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations 50 to 150 feet from the site boundary were not elevated above background levels (<0.2 mG).

Table 6 reveals that there are significant magnetic fields at locations a few feet from inverters, in the range of 200 to 500 mG. These levels drop back to background levels (<0.2 mG) at distances of 95 to 150 feet from the inverters. The variation of magnetic field with distance shown in Table 6 generally shows the field strength is proportional to the inverse cube of the distance from equipment.

TABLE 4

SOUND AND EMF LEVELS MEASURED AT SITE 2
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	53.3	54.4	0.2	< 5
South West Boundary	52.4	54.4	0.2	< 5
South East Boundary	48.3	50.8	0.4	< 5
North East Boundary	46.8	49.8	< 0.2	< 5
Background Mean Values	49.6	53.1	< 0.2	< 5
Set back 50 feet from Boundary	50.3	52.3	< 0.2	< 5
Set back 100 feet from Boundary	49.9	55.9	< 0.2	< 5
Set back 150 feet from Boundary	48.6	51.0	< 0.2	< 5

TABLE 5

SOUND LEVELS MEASURED AT SITE 2
EQUIPMENT PAD

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
Parallel to Inverter Face / 10 feet	46.7	48.1
Parallel to Inverter Face / 20 feet	44.8	46.2
Parallel to Inverter Face / 30 feet	44.3	45.6
Parallel to Inverter Face / 95 feet*	44.0	45.6
Perpendicular to Inverter Face / 10 feet	59.9	60.8
Perpendicular to Inverter Face / 20 feet	57.3	58.7
Perpendicular to Inverter Face / 30 feet	53.4	54.5
Perpendicular to Inverter Face / 150 feet	46.2	47.5

*Measurements could not be taken at 150 feet parallel to inverter face because of the close proximity of wetlands. Instead, a measurement was made at the farthest practical distance in that direction at 95 feet.

TABLE 6

EMF LEVELS MEASURED AT SITE 2
EQUIPMENT PAD

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 4 feet	200	< 5
Parallel to Inverter Face / 8 feet	10	< 5
Parallel to Inverter Face / 12 feet	0.8	< 5
Parallel to Inverter Face / 95 feet*	<0.2	< 5
Perpendicular to Inverter Face / 4 feet	500	< 5
Perpendicular to Inverter Face / 8 feet	25	< 5
Perpendicular to Inverter Face / 12 feet	4.5	< 5
Perpendicular to Inverter Face / 150 feet	<0.2	< 5

*Measurements could not be taken at 150 feet parallel to inverter face because of the close proximity of wetlands. Instead, a measurement was made at the farthest practical distance in that direction at 95 feet.

Figure 6. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #2

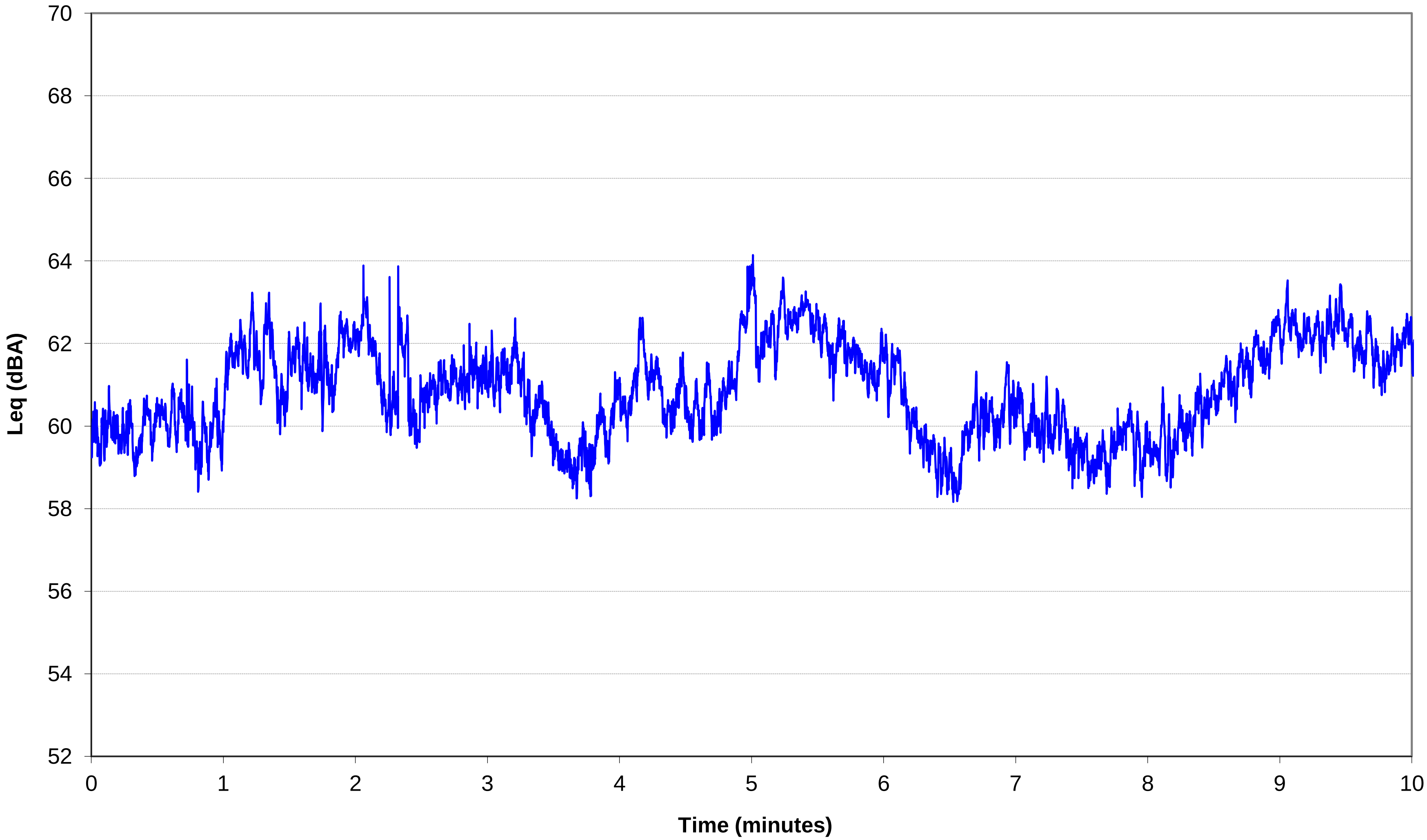


Figure 7. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #2 - First 10 Seconds of Measurements

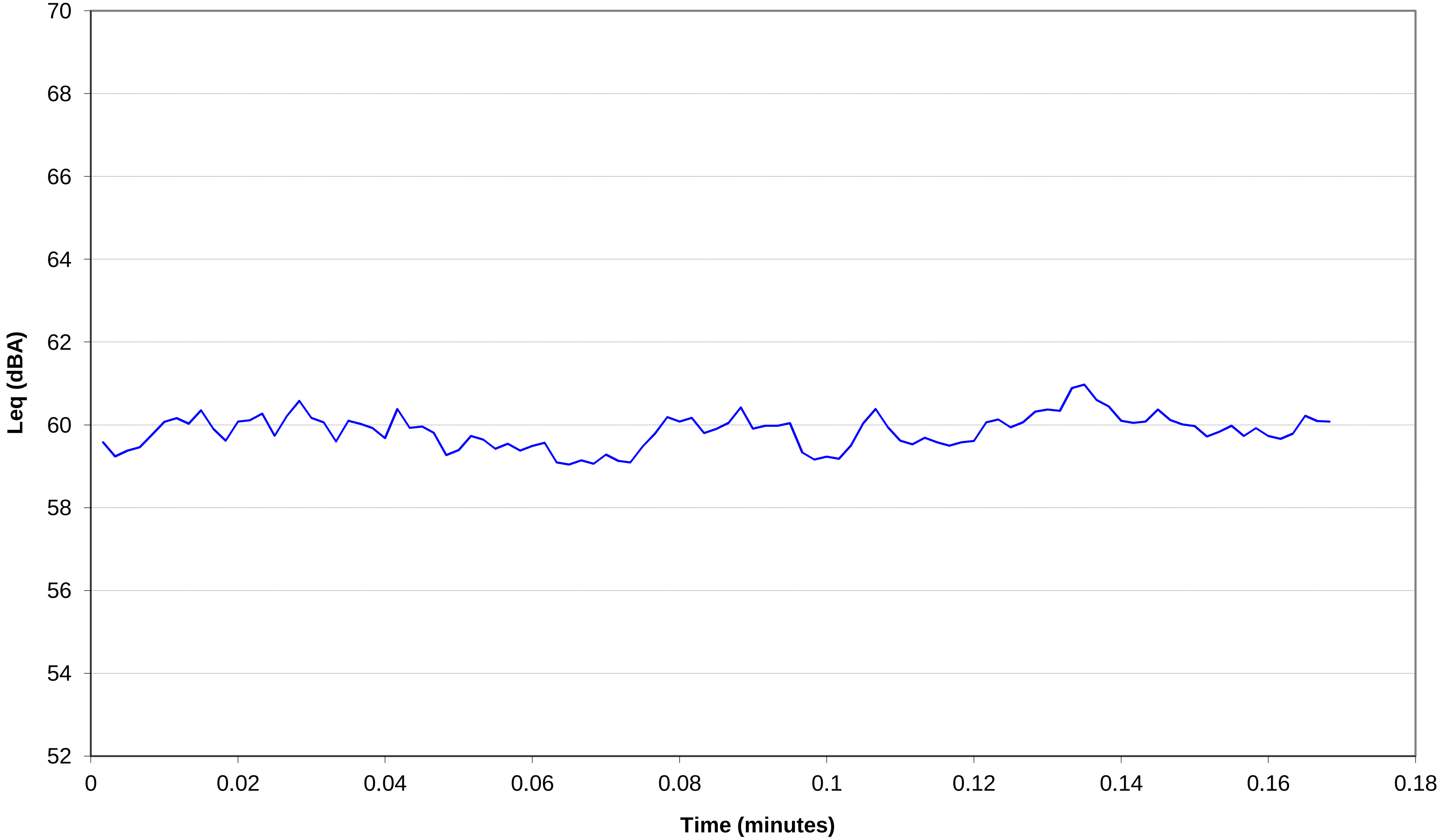
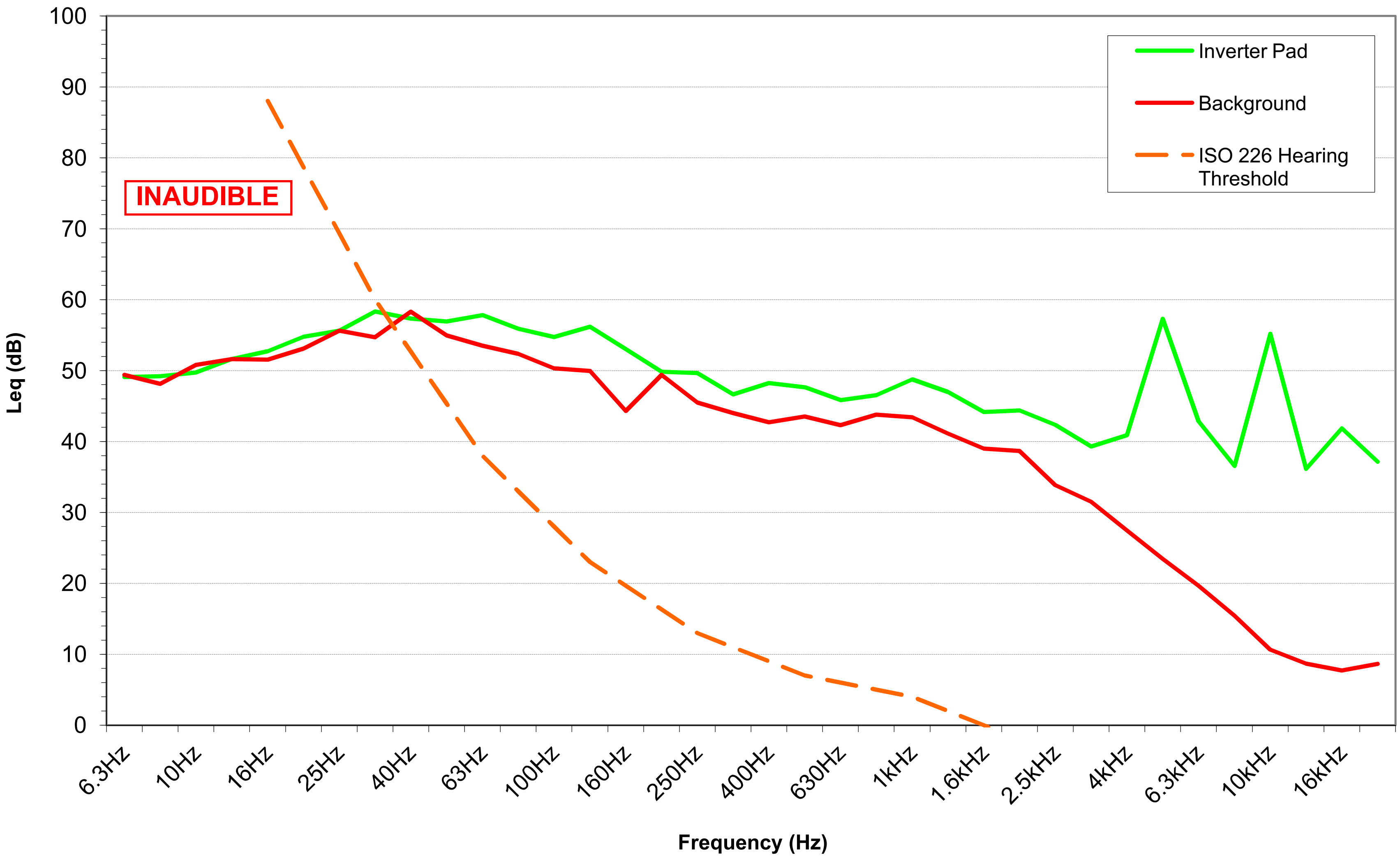


Figure 8. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad at Site #2



3.3 Site 3 – Norfolk Solar

Facility Location:	33 Medway Branch Road, Norfolk, MA
Facility Owner:	Constellation Solar Massachusetts, LLC
System Capacity:	1,375 kW
Power Output During Monitoring:	1,200 to 1,375 kW
No. & Size Inverters:	(2) 500-kW inverters and (1) 375-kW inverter
Date Measured:	Monday October 22, 2012
Sky Cover:	10% (passing small cumulus clouds)
Winds:	West 10-12 mph
Ground:	One PV array sits high on top of the closed landfill with grass cover and no surrounding vegetation. The other, larger PV array is in a wooded area on relatively flat ground. Measurements were made at the larger PV array.
Background Sound:	Mean value L_{eq} of 45.3 dBA (range of 43.1 to 47.5 dBA). Mean value L_{90} of 42.5 dBA (range of 42.1 to 43.2 dBA). Sources included distant traffic noise and natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m).

There are two solar photovoltaic arrays on the land of the Town of the Norfolk Department of Public Works. One array sits on top of a capped landfill and has a single equipment pad with one inverter. The second, and larger, array is in a cleared flat area east of the capped landfill and has a single equipment pad housing two inverters. The boundaries of the PV arrays are fenced. The surrounding area has only grass cover or low vegetation. Measurements were made at the larger PV array and at the equipment pad housing two inverters with a capacity of 875 kW. The sound and EMF measurements made at Site 3 are summarized in Tables 7 through 9. Figures 9 and 10 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location (1X) for the equipment pad, while Figure 11 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

<u>Sound Levels</u>

Background sound levels were fairly constant across the site and distant roadway traffic was the primary background sound source. The background mean value L_{eq} and L_{90} levels were 45.3 dBA and 42.5 dBA, respectively. The PV array was inaudible outside of the fenced boundary except at the South East boundary location where a faint inverter hum could be heard. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the equipment pad (which holds two inverters) were 54.8 to 60.9 dBA. Along the axis perpendicular to the inverter face measured sound levels were 6 to 7 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels generally followed the expected hemispherical wave spreading law (approximately -6 dB per doubling of distance). At a distance of 150 feet, all inverter sounds were below background sound levels.

The time domain analysis presented in Figures 9 and 10 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 3 to 4 dBA. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. Between 7 and 9 minutes into the 10-minute measurement, clouds passed over the face of the sun, power production dropped, and the inverter cooling fans turned off for a brief period, as shown by the abrupt 4 dBA drop in sound level in Figure 9.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 11) shows energy peaks in four 1/3-octave bands: 63, 125, 5,000 and 10,000 Hz. The high frequency peaks produce the characteristic “ringing noise” or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak in each pair is a first-harmonic tone (10 kHz being twice the frequency of 5 kHz). The tonal sound exhibited by Figure 11 is not, however, audible at distances of 50 to 150 feet beyond the site boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 11. The dashed line in Figure 11 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum declines smoothly with increasing frequency in the audible range except for a slight rise around 800 to 2,000 Hz caused by distant roadway traffic noise.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the site boundary, are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels along the PV array boundary were in the very low range, at or below 0.2 mG. Magnetic field levels at the locations 50 to 150 feet from the site boundary were not elevated above background levels (<0.2 mG).

Table 9 reveals that there are significant magnetic fields at locations a few feet from inverters, in the range of 150 to 500 mG. These levels drop back to levels of 0.4 mG in the perpendicular direction and to background levels (<0.2 mG) in the parallel direction at 150 feet from the inverters. The variation of magnetic field with distance shown in Table 9 generally shows the field strength is proportional to the inverse cube of the distance from equipment.

TABLE 7

SOUND AND EMF LEVELS MEASURED AT SITE 3
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	46.2	48.3	< 0.2	< 5
South West Boundary	48.9	50.6	< 0.2	< 5
South East Boundary	43.3	44.3	0.2	< 5
North East Boundary	43.9	46.1	< 0.2	< 5
Background Mean Values	42.5	45.3	< 0.2	< 5
Set back 50 feet from Boundary	43.2	47.5	< 0.2	< 5
Set back 100 feet from Boundary	42.2	45.4	< 0.2	< 5
Set back 150 feet from Boundary	42.1	43.1	< 0.2	< 5

TABLE 8

SOUND LEVELS MEASURED AT SITE 3
EQUIPMENT PAD

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
Perpendicular to Inverter Face / 10 feet	59.7	60.9
Perpendicular to Inverter Face / 20 feet	57.3	58.6
Perpendicular to Inverter Face / 30 feet	49.4	50.1
Perpendicular to Inverter Face / 150 feet	43.9	47.0
Parallel to Inverter Face / 10 feet	53.9	54.8
Parallel to Inverter Face / 20 feet	50.6	51.3
Parallel to Inverter Face / 30 feet	45.5	48.0
Parallel to Inverter Face / 150 feet	41.8	43.7

TABLE 9

EMF LEVELS MEASURED AT SITE 3
EQUIPMENT PAD

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 3 feet	150	< 5
Parallel to Inverter Face / 6 feet	10	< 5
Parallel to Inverter Face / 9 feet	5	< 5
Parallel to Inverter Face / 150 feet	< 0.2	< 5
Perpendicular to Inverter Face / 3 feet	500	< 5
Perpendicular to Inverter Face / 6 feet	200	< 5
Perpendicular to Inverter Face / 9 feet	80	< 5
Perpendicular to Inverter Face / 150 feet	0.4	< 5

Figure 9. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #3

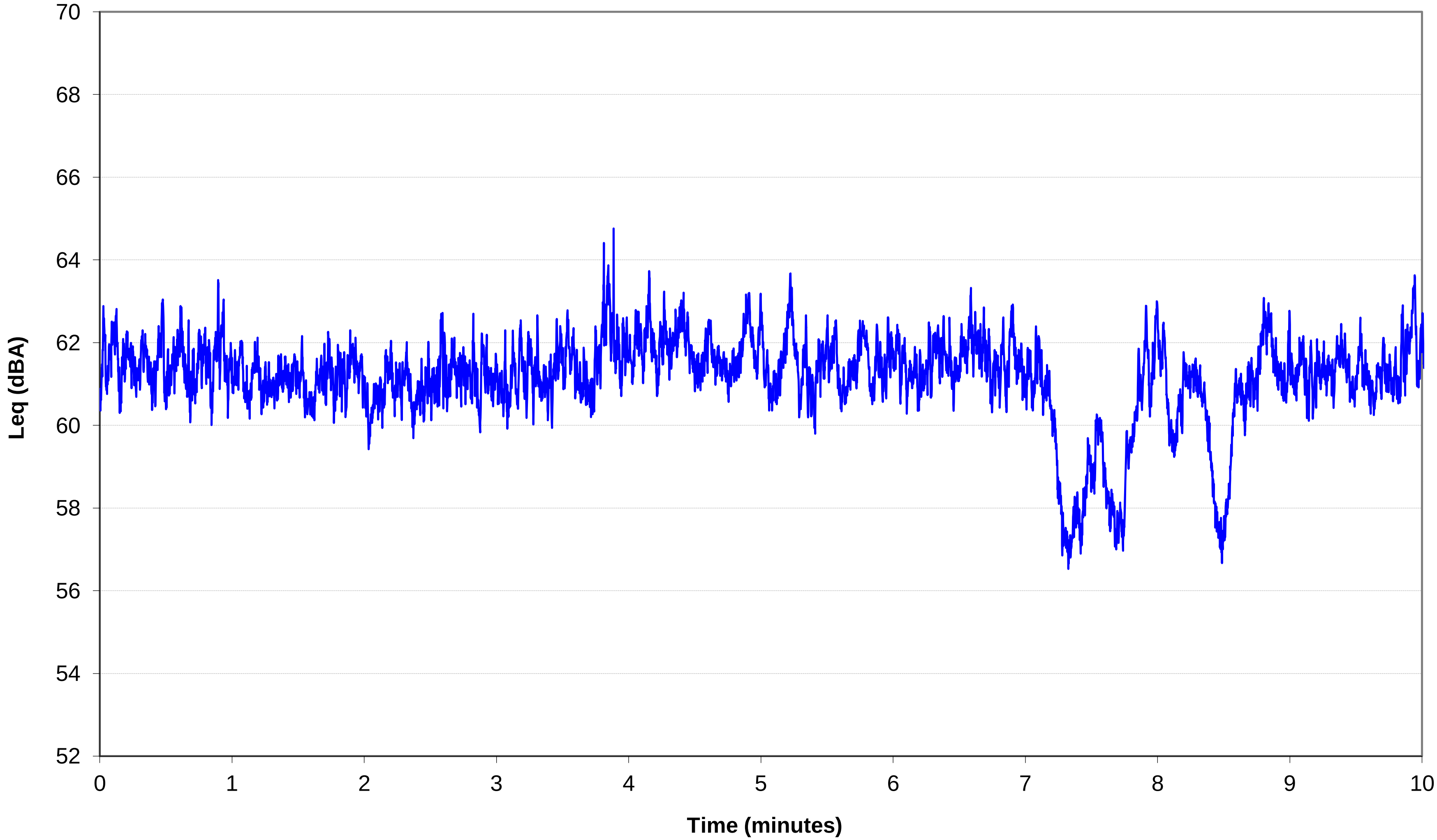


Figure 10. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #3 - First 10 Seconds of Measurements

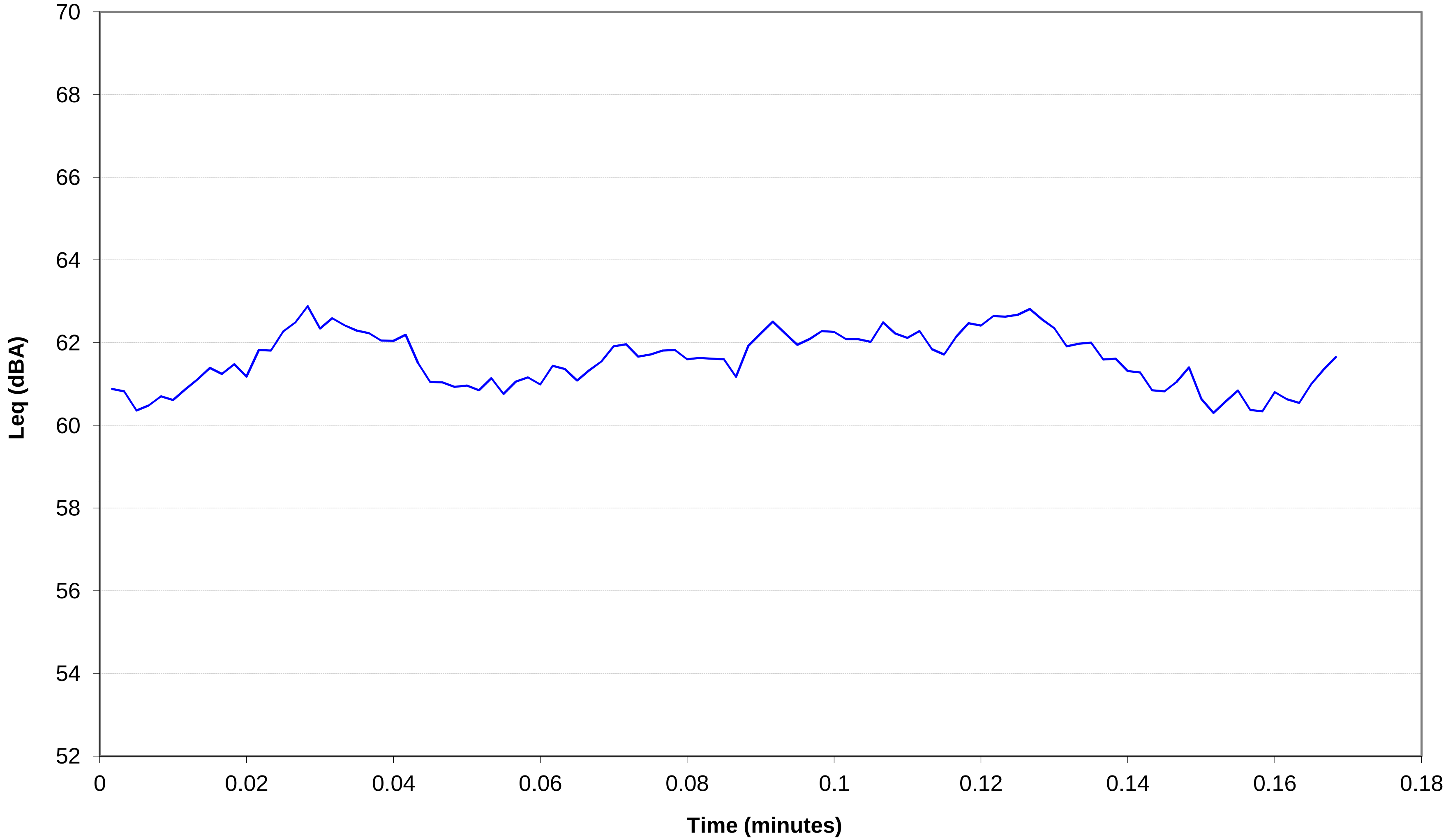
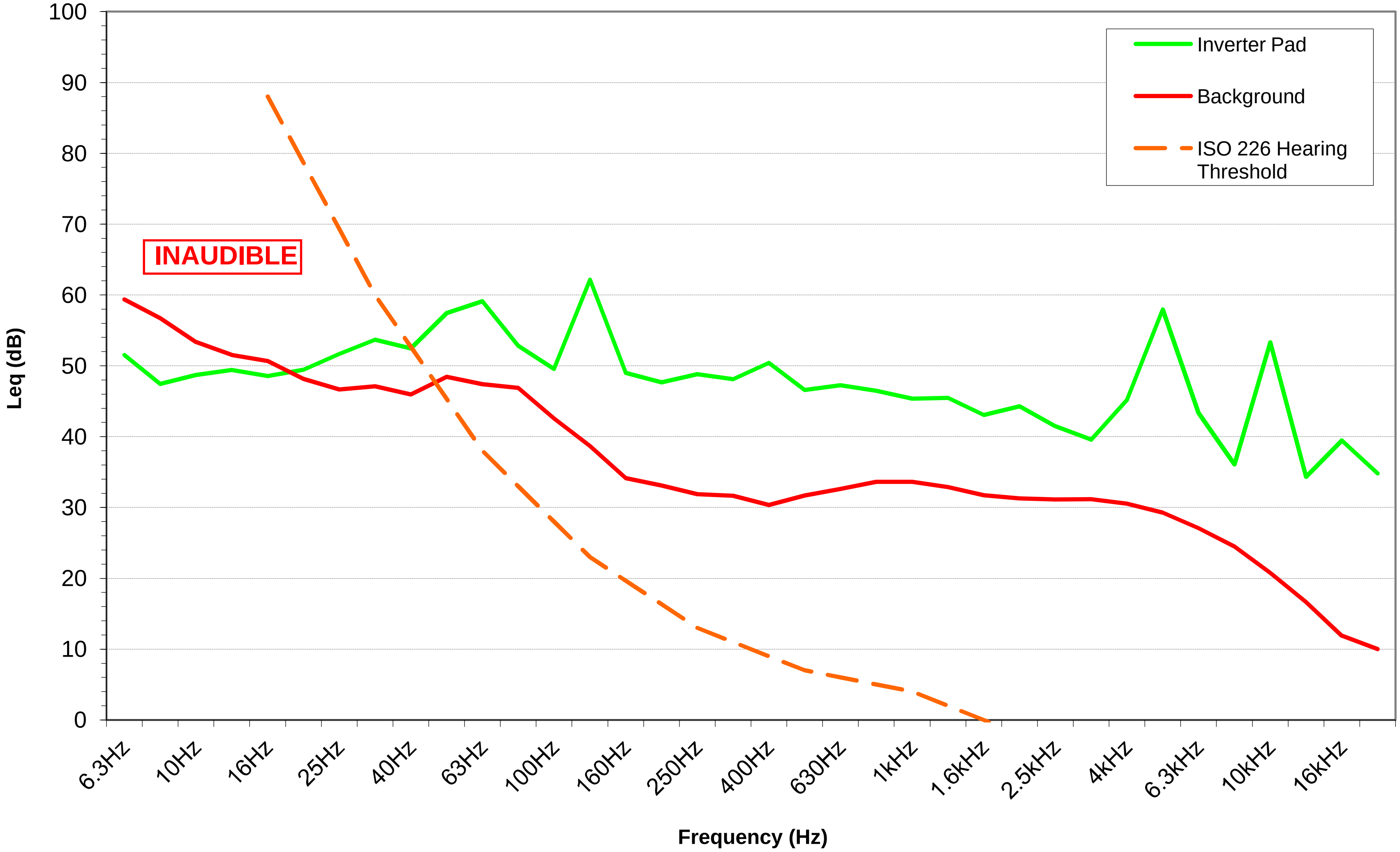


Figure 11. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad at Site #3



3.4 Site 4 – Residential Solar at Mass. Audubon Society in Sharon

Facility Location:	Moose Hill Sanctuary, 293 Moose Hill Road, Sharon, MA
Facility Owner:	Massachusetts Audubon Society
System Capacity:	8.6 kW
Power Output During Monitoring:	4.2 kW
No. & Size Inverters:	(1) 5-kW inverter and (1) 3.6-kW inverter
Date Measured:	Friday October 26, 2012
Sky Cover:	50% (scattered clouds)
Winds:	Northwest 0-3 mph
Ground:	(42) Evergreen solar panels are mounted on the pitched roof of the two-story building and face south. The ground around the site is cleared and opens to the south with surrounding woods at a distance.
Background EMF:	None in occupied rooms (< 0.2 mG and < 5 V/m). In the basement storage space where the inverters were housed, a background magnetic field of 2 mG was present and the background electric field was < 5 V/m.

EMF measurements were made inside the headquarters building of the Massachusetts Audubon Moose Hill Sanctuary. No sound measurements were made for this residential sized solar installation. The EMF measurements were made in rooms on the second floor of the building, the closest locations occupants have to the roof-mounted panels. Measurements were also made at the inverters inside the basement of the building, in a space not readily accessible to the public. The EMF measurements made at Site 4 are summarized in Tables 10 and 11.

Electric Fields

Electric field levels in the rooms on the top floor, nearest the roof-mounted solar panels are not elevated above background levels (< 5 V/m). In the basement, electric fields near the inverters (3 feet) are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels in the rooms on the top floor, nearest the roof-mounted solar panels were in the very low range of 0.2 to 1.4 mG. Table 11 reveals that there are low-level magnetic fields at locations a few feet from inverters, around 6 to 10 mG. These levels dropped back to a floor of 2 mG at a distance of 6 to 9 feet from the inverters. Nearby electrical lines and other equipment in the basement created a background of 2 mG in the space where the inverters were housed.

TABLE 10

EMF LEVELS MEASURED INSIDE THE RESIDENTIAL BUILDING, TOP FLOOR AT SITE 4

Boundary Location	Magnetic Field (mG)	Electric Field (V/m)
North West Room	0.9	< 5
South West Room	1.4	< 5
South East Room	0.2	< 5
North East Room	0.5	< 5

TABLE 11

EMF LEVELS MEASURED INSIDE THE RESIDENTIAL BUILDING, BASEMENT AT SITE 4

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 3 feet	10	< 5
Parallel to Inverter Face / 6 feet	6	< 5
Parallel to Inverter Face / 9 feet	2	< 5
Parallel to Inverter Face / 15 feet	2	< 5
Perpendicular to Inverter Face / 3 feet	6	< 5
Perpendicular to Inverter Face / 6 feet	2	< 5
Perpendicular to Inverter Face / 9 feet	2	< 5
Perpendicular to Inverter Face / 15 feet	2	< 5

4.0 CONCLUSIONS

Sound pressure level and electromagnetic field (EMF) measurements were made at three utility-scale PV arrays with a capacity range of 1,000 to 3,500 kW under a full-load condition with sunny skies and the sun at approximately 40^{o} azimuth. Measurements were taken at set distances from the inverter pads and along the fenced boundary of the PV array. Measurements were also made at set distances back from the boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of sound levels from the equipment.

EMF Measurements were also made at one residential[6] PV installation with a capacity of 8.6 kW under a partial-load condition. PV array operation is related to the intensity of solar insolation. Less sunshine results in lower sound and EMF levels from the equipment, and no sound or EMF is produced at night when no power is produced. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

Sound Levels

At the utility scale sites, sound levels along the fenced boundary of the PV arrays were generally at background levels, though a faint inverter hum could be heard at some locations along the boundary. Any sound from the PV array and equipment was inaudible and sound levels are at background levels at set back distances of 50 to 150 feet from the boundary.

Average L_{eq} sound levels at a distance of 10 feet from the inverter face varied over the range of 48 dBA to 61 dBA for Site 2 and Site 3 Inverters[7], and were higher in the range of 59 to 72 dBA for Site 1 Inverters. Along the axis perpendicular to the plane of the inverter face and at distances of 10 to 30 feet, sound levels were 4 to 13 dBA higher compared to levels at the same distance along the axis parallel to the plane of the inverter face. At a distance of 150 feet from the inverter pad, sound levels

[6] Only EMF measurements were made at the residential site.

[7] The same make of inverters were used at Sites 2 and 3.

approached background levels. Sound level measurements generally followed the hemispherical wave spreading law (-6 dB per doubling of distance).

The time domain analysis reveals that 0.1-second L_{eq} sound levels at a distance of 10 feet from an inverter pad generally varied over a range of 2 to 6 dBA, and no recurring pattern in the rise and fall of the inverter sound levels with time was detected. The passage of clouds across the face of the sun caused cooling fans in the inverters to briefly turn off and sound levels to drop 4 dBA.

The 1/3-octave band frequency spectrum of equipment sound at the close distance of 10 feet shows energy peaks in several mid-frequency and high-frequency bands, depending on the inverter model. Tonal sound was found to occur in harmonic pairs: 63/125 Hz; 315/630 Hz; 3,150/6,300 Hz; and 5,000/10,000 Hz. The high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The tonal sound was not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum. All low-frequency sound from the inverters below 40 Hz is inaudible, at all distances.

Electric Fields

The International Commission on Non-Ionizing Radiation Protection has a recommended exposure limit of 4,200 V/m for the general public. At the utility scale sites, electric field levels along the fenced PV array boundary, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels (< 5 V/m). Electric fields near the inverters were also not elevated above background levels (< 5 V/m).

At the residential site, indoor electric fields in the rooms closest to the roof-mounted panels and at locations near the inverters were not elevated above background levels (< 5 V/m).

Magnetic Fields

The International Commission on Non-Ionizing Radiation Protection has a recommended exposure limit of 833 mG for the general public. At the utility scale sites, magnetic field levels along the fenced PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations

50 to 150 feet from the array boundary were not elevated above background levels (<0.2 mG). There are significant magnetic fields at locations a few feet from inverters, in the range of 150 to 500 mG. At a distance of 150 feet from these utility-scale inverters, these fields drop back to very low levels of 0.5 mG or less, and in many cases to background levels (<0.2 mG). The variation of magnetic field with distance generally shows the field strength is proportional to the inverse cube of the distance from equipment.

At the residential site, indoor magnetic field levels in the rooms closest to the roof-mounted panels were in the low range of 0.2 to 1.4 mG. There are low-level magnetic fields at locations a few feet from the inverters, in the range of 6 to 10 mG. At a distance of no more than 9 feet from the inverters, these fields dropped back to the background level at the residential site of 2 mG. Due to the relatively high background level in the residential site basement where the inverters were housed, the relationship of magnetic field strength to distance from the inverters could not be discerned.

APPENDIX A

ACOUSTIC TERMS AND METRICS

All sounds originate with a source – a human voice, vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person's ears as sound waves, which are minute variations in air pressure. The loudness of a sound depends on the **sound pressure level**[8], which has units of decibel (dB). The **decibel scale** is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. On this scale, the quietest sound we can hear is 0 dB, while the loudest is 120 dB. Every 10-dB increase is perceived as a doubling of loudness. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 dB to 90 dB.

A property of the decibel scale is that the numerical values of two separate sounds do not directly add. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB) on the decibel scale, not a doubling to 140 dB. In terms of sound perception, 3 dB is the minimum change most people can detect. In terms of the human perception of sound, a halving or doubling of loudness requires changes in the sound pressure level of about 10 dB; 3 dB is the minimum perceptible change for **broadband** sounds, i.e. sounds that include all frequencies. Typical sound levels associated with various activities and environments are presented in Table A-1. The existing sound levels at a PV project site are determined primarily by the proximity to roads and highways, the source of traffic noise. Sound exposure in a community is commonly expressed in terms of the **A-weighted sound level (dBA)**; A-weighting approximates the frequency response of the human ear and correlates well with people's perception of loudness.

The level of most sounds change from moment to moment. Some are sharp impulses lasting one second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. The equivalent sound level $\mathbf{L_{eq}}$ is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the energy-average sound

[8] The sound pressure level is defined as $20*\log_{10}(P/P_o)$ where P is the sound pressure and P_o is the reference pressure of 20 micro-Pascals (20 μPa), which by definition corresponds to 0 dB.

level and it includes in its measure all of the sound we hear. EPA has determined that the $\mathbf{L_{eq}}$ average sound level correlates best with how people perceive and react to sound.[9]

To establish the background sound level in an area, the $\mathbf{L_{90}}$ metric, which is the sound level exceeded 90% of the time, is typically used. The $\mathbf{L_{90}}$ can be thought of as the level representing the quietest 10% of any time interval. The $\mathbf{L_{90}}$ is a broadband sound pressure measure. By definition, the $\mathbf{L_{90}}$ metric will filter out brief, loud sounds, such as intermittent traffic on a nearby roadway.

Sound pressure level measurements typically include an analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is **Hertz (Hz)**, measuring the cycles per second of the sound pressure waves. In the physiology of human hearing, every octave jump of a tone corresponds to a doubling of the sound frequency in Hz. For example, Middle-C on a piano has a frequency of approximately 260 Hz. High-C, one octave above, has a frequency of approximately 520 Hz. The hearing range for most people is 20 Hz to 20,000 Hz. In acoustic studies, the sound spectrum is divided into **octave bands** with center frequencies that are an octave apart, or 1/3-octave bands with center frequencies that are 1/3 of an octave apart. There are 11 whole octave bands centered in the audible range from 20 to 20,000 Hz. For the extended frequency range of 6.3 Hz to 20,000 Hz used in this study, there are 36 1/3-octave bands.

Low-frequency sound generally refers to sounds below 250 Hz in frequency, which is close to the tone of Middle-C on a piano. **Infrasound** is low-frequency sound at frequencies below 20 Hz, a sound wave oscillating only 20 cycles per second. For comparison, the lowest key on a piano produces a tone of 28 Hz, and human speech is in the range of 500 to 2,000 Hz. The hearing threshold for infrasound at 16 Hz is 90 decibels (dB).[10] We are enveloped in naturally occurring infrasound, which is inaudible. Infrasound is always present in the outdoor environment due to sounds generated by air turbulence, shoreline waves, motor vehicle traffic and distant aircraft.

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[9] U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Publication EPA-550/9-74-004.

[10] International Standards Organization, ISO 226:2003.

TABLE A-1

VARIOUS INDOOR AND OUTDOOR SOUND LEVELS

Outdoor Sound Levels	Sound Pressure (μPa)		Sound Level (dBA)	Indoor Sound Levels
	6,324,555	-	110	Rock Band at 5 m
Jet Over-Flight at 300 m		-	105	
	2,000,000	-	100	Inside New York Subway Train
Gas Lawn Mower at 1 m		-	95	
	632,456	-	90	Food Blender at 1 m
Diesel Truck at 15 m		-	85	
Noisy Urban Area--Daytime	200,000	-	80	Garbage Disposal at 1 m
		-	75	Shouting at 1 m
Gas Lawn Mower at 30 m	63,246	-	70	Vacuum Cleaner at 3 m
Suburban Commercial Area		-	65	Normal Speech at 1 m
Quiet Urban Area -- Daytime	20,000	-	60	
		-	55	Quiet Conversation at 1m
Quiet Urban Area--Nighttime	6,325	-	50	Dishwasher Next Room
		-	45	
Suburban Area--Nighttime	2,000	-	40	Empty Theater or Library
		-	35	
Rural Area--Nighttime	632	-	30	Quiet Bedroom at Night
		-	25	Empty Concert Hall
Rustling Leaves	200	-	20	Average Whisper
		-	15	Broadcast and Recording Studios
	63	-	10	
		-	5	Human Breathing
Reference Pressure Level	20	-	0	Threshold of Hearing

Notes:
μPa - Micropascals describe sound pressure levels (force/area).
dBA - A-weighted decibels describe sound pressure on a logarithmic scale with respect to 20 μPa.

APPENDIX B

EMF TERMS AND METRICS

An electromagnetic field (**EMF**) is the combination of an **electric field** and a **magnetic field**. The electric field is produced by stationary charges, and the magnetic field by moving charges (currents). From a classical physics perspective, the electromagnetic field can be regarded as a smooth, continuous field, propagated in a wavelike manner. From the perspective of quantum field theory, the field is seen as quantized, being composed of individual particles (photons).

EMFs are present everywhere in our environment but are invisible to the human eye. For example, electric fields are produced by the local build-up of electric charges in the atmosphere associated with thunderstorms, and the earth's magnetic field causes a compass needle to orient in a North-South direction and is used for navigation. Besides natural sources, the electromagnetic spectrum also includes fields generated by man-made sources. For example, the electricity that comes out of every power socket has associated low frequency EMFs. A photovoltaic (PV) project generates low-frequency EMFs from inverters (that convert DC-current to AC-current), transformers (that step-up the PV project voltage), and current-carrying cables. The EMFs from PV project components are classified as "non-ionizing radiation," because the electromagnetic waves have low-energy quanta incapable of breaking chemical bonds in objects through which they pass.

The strength of the **electric field** is measured in volts per meter (**V/m**). Any electrical wire that is charged will produce an associated electric field. This field exists even when there is no current flowing. The higher the voltage, the stronger the electric field at a given distance from the wire. Magnetic fields arise from the motion of electric charges. The strength of the **magnetic field** is measured by the magnetic flux density in milli-Gauss (**mG**). In contrast to electric fields, a magnetic field is only produced once a device is switched on and current flows. The higher the current, the greater the strength of the magnetic field produced at a given distance. EMFs are strongest close to a source, and their strength rapidly diminishes with distance from it. Field strength is generally proportional to the inverse cube of the distance.

Typical household fixtures and appliances produce both types of fields. For example, at a distance of one foot from a fluorescent light, electric and magnetic fields of 50 V/m and 2 mG, respectively, are measured. At a distance of 1 inch from the power cord for an operating personal computer, fields of 40 V/m and 1 mG, respectively, are detected.

There are no federal, State or local regulatory exposure limits for electric or magnetic fields that apply to solar photovoltaic arrays. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has recommended exposure limits of 4,200 V/m and 833 mG for the general public. ICNIRP is an organization of 15,000 scientists in 40 nations who specialize in radiation protection, and their recommendations are routinely used in EMF exposure studies.

Exhibit B

Sungrow SG125HV String Inverter Noise Level Test Report

Sungrow ST556KWH-D250H Battery Noise Level Test Report

SG125HV Noise Level Test Report

Version	Date	Author	Approved by
V10	2017,May, 28	Bale, Yang	Chen W

1.Introduction

This document describes the noise level test for SG125HV.The test is conducted in the Sungrow Testing Center, which is a WMT testing lab (Witnessed Manufacturer's Testing) accredited by TUV, CSA and UL.

The test procedures are in accordance with the standard ISO3746 and the sound pressure level fulfills the requirements in the IEC62109-1 standard.

2.Noise Level Test

The noise test was completed in the shielding room using the test platform shown below:

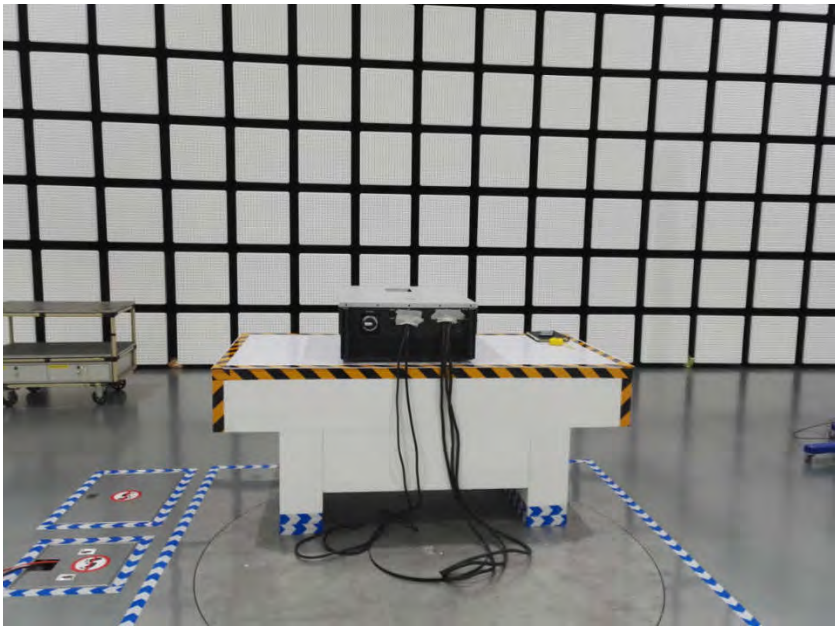

Fig-1 Noise Test Platform

During the test, the noise test instrument is located at a distance of 1m from the inverter, the inverter's operating DC voltage is 1050V and its output power is 125kW.The test data for the four directions and background noise are as follows:

Direction	**Test Data**
Bottom	61.6dB
Left Side	56.9dB
Top	53.7dB
Right Side	53.2dB
Background Noise	31.1dB

Appendix: Testing Pictures

Fig-2 Background Noise

Fig-3 Bottom Side

Fig-4 Left Side

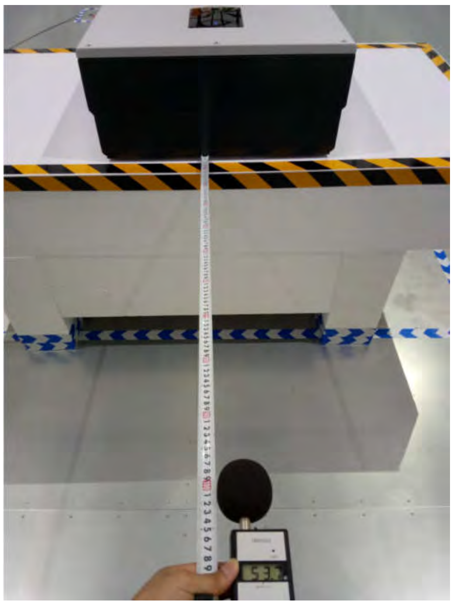

Fig-5Top Side

Fig-6Right Side

Test Report

Report Name	ST556KWH-D250HV+4SG125HV Noise Test Report	**Test Standard**	NB/T 32004-2018
Test Result	1. Noise test Pass		
Hardware Version	V11	**Software Version**	/
Test Number	1	**Test Time**	2020-04-24

Prepared by:	潘圆圆	**Reviewed by:**		**Approved by:**	
Date:	2020-04-24	**Date:**		**Date:**	

Content

1 Noise Test

1.1 Sample Information

Sample Name	Energy storage system project	**Sample Model**	ST556KWH-D250HV+4SG125HV
Sample Number	/	**Sample Size**	1
Receiving Date	/	**Sample Stage**	TR5
Sample Status	Intact		
Key Device	/		

1.2 Test Information

Applicant	Wu Xiaolei	**Department**	Energy Storage System Product Center
Test Item	Noise test	**Test Process**	/
Test Date	2020-04-24	**Tester**	Pan Yuanyuan
Test Environment	Temperature: 18.1℃ Humidity: 45.0%	**Test Location**	Sungrow industrial park
Test Standard	NB/T 32004-2018 Technical specification of PV grid-connected inverter		

1.3 Test Equipment

Equipment	Manufacturer	Model	Number	Calibration Date	Effective Date
Noise Meter	Hangzhou Aihua Instruments Co., Ltd.	AWA6218C	YQ-026	2019-10-28	2020-10-27

1.4 Test Conclusion and Judgement Basis

Test Position	Test Distance (m)	Test Noise Value（dB）	Limit (dB)	Conclusion (P/F)
Front	1	75.7	80(Specification)	P

Right side	1	63.3	80(Specification)	P
Left side	1	74.6	80(Specification)	P
Back	1	64.2	80(Specification)	P

1.5 Test Details

The machine is running at full power. When the machine is running stably, the fan running at full speed, and the air conditioning system turned on, a noise meter shall be used to measure the noise at a distance of 1m from each side of the EUT.

1.6 Test Record

<table>
<tr><th colspan="2">EUT noise</th></tr>
<tr><td>

Fig. 1-1 Front</td><td>

Fig. 1-2 Right Side</td></tr>
<tr><td>

Fig. 1-3 Left Side</td><td>

Fig. 1-4 Back</td></tr>
</table>

Fig. 1-5 AC Cabinet

Fig. 1-6 Background Noise

1.7 Appendix

N/A

Exhibit C

NEMA TR-1 Standards

NEMA Standards Publication No. TR 1-1993 (R2000)

Transformers, Regulators and Reactors

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

NEMA Standards Publication No. TR 1-1993 (R2000)

Transformers, Regulators and Reactors

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

TABLE OF CONTENTS

FOREWORD

The standards appearing in this publication have been developed by the Transformer Section and have been approved for publication by the National Electrical Manufacturers Association. They are used by the electrical industry to promote production economies and to assist users in the proper selection of transformers.

The Transformer Section is working actively with the American National Standards Committee, C57, on Transformers, Regulators and Reactors, in the development, correlation and maintenance of national standards for transformers. This Committee operates under the procedures of the American National Standards Institute (ANSI).

It is the policy of the NEMA Transformer Section to remove material from the NEMA Standards Publication as it is adopted and published in the American National Standard C57 series. The NEMA Standards Publication for Transformers, Regulators and Reactors references these and other American National Standards applying to transformers, and is intended to supplement, without duplication, the American National Standards.

The NEMA Standards Publication for Transformers, Regulators and Reactors contains provision for the following:

a. American National Standards adopted by reference and applicable exceptions approved by NEMA, if any.
b. NEMA Official Standards Proposals. These are official drafts of proposed standards developed within NEMA or in cooperation with other interested organizations, for consideration by ANSI. They have a maximum life of five years, during which time they may be approved as American National Standards or adopted as NEMA Standards, or rescinded.
c. Manufacturing Standards. These are NEMA Standards which are primarily of interest to the manufacturers of transformers and which are not yet included in an American National Standard.
d. Standards Which Are Controversial. These are NEMA Standards, on which there is a difference of opinion within Committee C57. The NEMA version will be included in the NEMA Standards Publication until such time as the differences between ANSI and NEMA are resolved.

NEMA Standards Publications are subject to periodic review and take into consideration user input. They are being revised constantly to meet changing economic conditions and technical progress. Users should secure latest editions. Proposed or recommended revisions should be submitted to:

Vice President, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037-1526

SCOPE

This publication provides a list of all ANSI C57 Standards that have been approved by NEMA. In addition it includes certain NEMA Standard test methods, test codes, properties, etc., of liquid-immersed transformers, regulators, and reactors that are not American National Standards.

PART 0
GENERAL

The following American National Standards have been approved as NEMA Standards and should be inserted in this Part 0:

ANSI/IEEE C57.12.00-1988	*General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers*
ANSI/IEEE C57.12.01-1989	*General Requirements for Dry Type Power and Distribution Transformers*
ANSI C57.12.10-1988	*Requirements for Transformers 230,000 volts and below, 833/958-8333/10,417 kVA single-phase 750/862-60,000/80,000/100,000 kVA three phase, including supplements*
ANSI C57.12.70-1993	*Terminal Markings and Connections for Distribution and Power Transformers*
ANSI/IEEE C57.12.90-1993	*Test Code for Liquid-immersed Distribution, Power & Regulating Transformers and Guide for Short-Circuit Testing of Distribution & Power Transformers*
ANSI/IEEE C57.19.00-1992	*General Requirements and Test Procedure for Outdoor Apparatus Bushings*
ANSI/IEEE C57.19.01-1992	*Standard Performance Characteristics & Dimensions for Outdoor Apparatus Bushings*
ANSI/IEEE C57.92-1992	*Guide for Loading Mineral-oil-immersed Power Transformers up to and including 100 MVA with 55C or 65C Average Winding Rise*

The NEMA Standards TR 1-0.01 through TR 1-0.09 on the following pages (see Part 0 Pages 1–9) also apply generally to transformers.

0.01 PREFERRED VOLTAGE RATINGS

Preferred system voltages and corresponding transformer voltage ratings are given in the American National Standard for Electric Power Systems and Equipment--Voltage Ratings (60 Hz), C84.1-1989. It is recommended that these ratings be used as a guide in the purchase and operation of transformers.

0.02 FORCED-AIR (FA) AND FORCED-OIL (FOA) RATINGS

Under the conditions of par. 5.11 of American National Standard ANSI/IEEE C57.12.00-1988, the relationship between self-cooled ratings and forced-air-cooled or forced-oil-cooled ratings shall be in accordance with Table 0-1.

Table 0-1
FORCED-AIR AND FORCED-OIL RATINGS RELATIONSHIPS

Class	Self-cooled Ratings* (kVA) Single Phase	Three Phase	Percent of Self-Cooled Ratings With Auxiliary Cooling First Stage	Second Stage
OA/FA	501-2499	501-2499	115	--
OA/FA	2500-9999	2500-11999	125	--
OA/FA	10000 and above	12000 and above	133-1/3	--
OA/FA/FA	10000 and above	12000 and above	133-1/3	166-2/3
OA/FA/FOA	10000 and above	12000 and above	133-1/3	166-2/3
OA/FOA/FOA	10000 and above	12000 and above	133-1/3	166-2/3

*In the case of multi-winding transformers or autotransformers, the ratings given are the equivalent two-winding ratings.

PERFORMANCE

0.03 RADIO INFLUENCE VOLTAGE LEVELS

The following values apply to liquid-filled transformers. They do not apply to load tap changing during switching or to operation of auxiliary relays and control switches.

0.03.1 Distribution Transformers

Radio influence voltage levels for distribution transformers, for systems rated 69 kV and less, shall not exceed 100 microvolts when measured in accordance with Section 7.01. The test voltage shall be the line-to-neutral voltage corresponding to 110 percent excitation of the transformer. This will be the coil voltage for wye connections and 1/3 times the coil voltage for delta connections.

0.04 POWER FACTOR OF INSULATION OF OIL-IMMERSED TRANSFORMERS

While the real significance which can be attached to the power factor of oil-immersed transformers is still a matter of opinion, experience has shown that power factor is helpful in assessing the probable conditions of the insulation when good judgement is used.

The proper interpretation of power factor of oil-immersed transformers is being given careful attention by manufacturers in connection with the problems of (1) selecting insulating materials, (2) sealing, and (3) processing the transformers. However, it is the comparative values which are guides for the successful solution for these problems rather than an absolute value of power factor.

The generally accepted factory tests for proving the insulation level are the prescribed low-frequency tests and impulse tests given in the American National Standard C57.12.90-1993.

When required, a factory power-factor test can be made, and this measurement will be of value for comparison with field power-factor measurements to assess the probable condition of the insulation. It is not feasible to establish standard power-factor values for oil-immersed transformers because:

a. Experience has definitely proved that little or no relation exists between power factor and the ability of the transformer to withstand the prescribed dielectric tests.

b. Experience has definitely proved that the variation in power factor with temperature is substantial and erratic so that no single correction curve will fit all cases.

When a factory power-factor measurement of a transformer is required, the measurement should be made with the insulation at room temperature, preferably at or close to 20°C.

0.05 AUDIBLE SOUND LEVELS

Transformers shall be so designed that the average sound level will not exceed the values given in Tables 0-2 through 0-4 when measured at the factory in accordance with the conditions outlined in ANSI/IEEE C57.12.90-1993.

The guaranteed sound levels should continue to be per Tables 0-2 through 0-4 until such time as enough data on measured noise power levels becomes available.

Sound pressure levels are established and published in this document. Sound power may be calculated from sound pressure, using the method described in C57.12.90-1993.

Rectifier, railway, furnace, grounding, mobile and mobile unit substation transformers are not covered by the tables. The tables do not apply during the time that power switches are operating in load-tap-changing transformers and in transformers with integral power switches.

ble 0-2
AUDIBLE SOUND LEVELS F(.-IMMERSED POWER TRANSFORMERS

Column 1 - Class*OA, Ow and FOW Ratings
Column 2 - Class* FA and FOA First stage Auxiliary Cooling**†
Column 3 - Straight FOA* Ratings, FA* FOA* Second-stage Auxiliary Cooling*†

Average Sound	Equivalent Two-winding Rating▲																	
Level ††,	350 kV BIL and Below			450, 550, 650 kV BIL			750 and 825 kV BIL			900 and 1050 kV BIL			1175 kV BIL			1300 kV BIL and Above		
Decibels	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
57	700	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...
58	1000	.	..	...	..	..	...	...	...	...	...	...	...	...	...	...	...	...
59	--	..	...	700	...	...	...	...	...	...	...	...	...	...	...	...	...	...
60	1500	..	..	1000	...	...	..	..	...	...	...	...	...	...	...	...	...	...
61	2000	.	..	...	...	.	...	...	..	...	...	...	...	...	...	...	...	...
62	2500	...	...	1500	...	.	.	..	..	..	...	...	...	..	..	...	...	...
63	3000	...	...	2000	...	..	..	...	...	...	...	..	...	..	...	...	...	...
64	4000	...	...	2500	...	...	...	...	...	...	...	...	...	...	...	...	...	...
65	5000	...	...	3000	...	...	...	...	...	...	...	...	...	..	...	...	...	...
66	6000	...	...	4000	.	.	3000	...	...	...	...	...	...	...	...	...	...	...
67	7500	6250▲▲	..	5000	3750▲▲	..	4000	3125▲▲	..	..	...	..	...	..	...	...	...	...
68	10000	7500		6000	5000	.	5000	3750	...	..	...	..	...	...	...	...	...	...
69	12500	9375	.	7500	6250	..	6000	5000	...	...	...	...	...	...	...	...	...	...
70	15000	12500	.	10000	7500	..	7500	6250	..	...	...	...	..	..	...	...	...	...
71	20000	16667		12500	9375		10000	7500	...	...	...	...	...	...	...	...	...	...
72	25000	20000	20800	15000	12500	..	12500	9375	...	...	...	...	...	..	...	...	...	...
73	30000	26667	25000	20000	16667	...	15000	12500	...	12500	...	..	...	...	..	...	...	...
74	40000	33333	33333	25000	20000	20800	20000	16667	...	15000	...	...	12500	...	...	...	...	...
75	50000	40000	41667	30000	26667	25000	25000	20000	20800	20000	16667	...	15000	...	...	12500	...	...
76	60000	53333	50000	40000	33333	33333	30000	26667	25000	25000	20000	20800	20000	16667	..	15000	...	...
77	80000	66667	66667	50000	40000	41667	40000	33333	33333	30000	26667	25000	25000	20000	20800	20000	16667	...
78	100000	80000	83333	60000	53333	50000	50000	40000	41667	40000	33333	33333	30000	26667	25000	25000	20000	20800
79	...	106667	100000	80000	66667	66667	60000	53333	50000	50000	40000	41667	40000	33333	33333	30000	26667	25000
80	..	133333	133333	100000	80000	83333	80000	66667	66667	60000	53333	50000	50000	40000	41667	40000	33333	33333
81	...	...	166667	...	106667	100000	100000	80[illegible]0	83333	80000	66667	66667	60000	53333	50000	50000	40000	41667
82	...	...	200000	...	133333	133333	...	106667	100000	100000	80000	83333	80000	66667	66667	60000	53333	50000
83	..	...	250000	...	...	166667	...	133333	133333	...	106667	100000	100000	80000	83333	80000	66667	66667
84	..	...	300000	...	...	200000	...	...	166667	...	133333	133333	...	106667	100000	100000	80000	83333
85	..	...	400000	...	...	250000	...	...	200000	...	...	166667	...	133333	133333	...	106667	100000
86	...	...	...	...	...	300000	...	...	250000	...	...	200000	...	...	166667	...	133333	133333
87	...	...	...	...	...	400000	...	...	300000	...	...	250000	...	...	200000	...	...	166667
88	...	...	...	...	...	...	...	...	400000	...	...	300000	...	...	250000	...	...	200000
89	...	...	...	...	...	...	...	...	...	...	...	400000	...	...	300000	...	...	250000
90	...	...	...	...	...	..	...	...	...	...	...	...	...	...	400000	...	...	300000
91	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	400000

*Classes of cooling (see 2.6.1 of American National Standard C57.12.00-1988.
**First- and second-stage auxiliary cooling (see TR 1.0.02).
†For column 2 and 3 ratings, the sound levels are with the auxiliary cooling equipment in operation.
††For Intermediate kVA ratings, use the average sound level of the next larger kVA rating.
▲The equivalent two-winding 55°C or 65°C rating is defined as one-half the sum of the kVA rating of all windings.
▲▲Sixty-seven decibels for all kVA ratings equal to this or smaller.

Table 0-3
AUDIBLE SOUND LEVELS FOR LIQUID-IMMERSED DISTRIBUTION TRANSFORMERS AND NETWORK TRANSFORMERS

Equivalent Two-winding kVA	Average Sound Level, Decibels
0–50	48
51–100	51
101–300	55
301–500	56
750	57
1000	58
1500	60
2000	61
2500	62

Table 0-4
AUDIBLE SOUND LEVELS FOR DRY-TYPE TRANSFORMERS 15000-VOLT NOMINAL SYSTEM VOLTAGE AND BELOW

Equivalent Two-Winding kVA	Average Sound Level, Decibels		Equivalent Two-winding kVA	Average Sound Level, Decibels Ventilated Forced Air Cooled **,†
	Self-cooled Ventilated*	Self-cooled Sealed*		
0–50	50	50	...	...
51–150	55	55	...	...
151–300	58	57	3–300	67
301–500	60	59	301–500	67
501–700	62	61	501–833	67
701–1000	64	63	834–1167	67
1001–1500	65	64	1168–1667	68
1501–2000	66	65	1668–2000	69
2001–3000	68	66	2001–3333	71
3001–4000	70	68	3334–5000	73
4001–5000	71	69	5001–6667	74
5001–6000	72	70	6668–8333	75
6001–7500	73	71	8334–10000	76

* Class AA rating

**Does not apply to sealed-type transformers

†Class FA and AFA ratings

Part 1
POWER TRANSFORMERS

The American National Standard C57.12.10-1988 has been approved as a NEMA Standard for power transformers and should be inserted in this Part 1.

The ANSI/IEEE Standard C57.92-1992, has been approved by NEMA and should be inserted in this Part 1.

The following other parts of this NEMA Publication No. TR 1 shall also apply:

a. Part 1 General
b. Part 6 Terminology
c. Part 7 Test Code
d. Part 12 Underground-Type Three-Phase Distribution Transformer

Part 2
DISTRIBUTION TRANSFORMERS

The following American National Standards have been approved as NEMA Standards for distribution transformers and should be inserted in this Part 2:

ANSI C57.12.20-1988	*Requirements for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34500 Volts and Below; Low Voltage, 7970/13800Y Volts and Below*
ANSI C57.12.21-1980	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; (High-Voltage, 34500 Grd Y/19920 Volts and Below; Low-Voltage, 240/120 Volts; 167 kVA and Smaller)*
ANSI C57.12.22-1989	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings 2500 kVA and Smaller; High-Voltage, 34500 Grd Y/19920 Volts and Below; Low Voltage, 480 Volts and Below*
ANSI C57.12.23-1992	*Requirements for Underground-Type Self-Cooled Single-Phase Distribution Transformers, with Separable Insulated High-Voltage Connectors; High-Voltage 24940 Grd Y/14400 Volts and Below; Low-Voltage 240/120; 167 kVA and Smaller*
ANSI C57.12.25-1990	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors: High-Voltage 34500 Grd Y/19920 Volts and below: Low-Voltage 240/120 Volts; 167 kVA and Smaller*
ANSI C57.12.26-1987	*Pad-Mounted Compartmental-Type Self-Cooled, Three-Phase Distribution Transformers for use with Separable High-Voltage Connectors (High-Voltage 34500 Grd Y/19920 Volts and Below: 2500 kVA and Smaller)*
ANSI C57.91-1992	*Guide for Loading Mineral Oil-Immersed Overhead-type Distribution Transformers with 55C or 65C Average Winding Rise*

The following parts of this NEMA Publication No. TR 1 shall apply for distribution transformers:

Part 0	General
Part 6	Terminology
Part 7	Test Code
Part 12	Underground-type Three-Phase Distribution Transformers

2.01 DESIGN TEST FOR ENCLOSURE SECURITY OF PADMOUNTED COMPARTMENTAL TRANSFORMERS

This standard provides a means for evaluating the security of enclosures for transformers conforming to the following American National Standards.

ANSI C57.12.21-1980	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; High-Voltage, 34500 Grd Y/19920 Volts and Below; Low-Voltage, 240/120 Volts; 167 kVA and Smaller*
ANSI C57.12.22-1989	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings 2500 kVA and smaller; High-Voltage, 34500 Grd Y/19920 Volts and Below; Low Voltage 480 Volts and Below*
ANSI C57.12.25-1990	*Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors: High-Voltage 34500 Grd Y/19920 Volts and below: Low-Voltage 240/120 Volts; 167 kVA and Smaller*

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ANSI C57.12.26-1987	*Pad-Mounted Compartmental-Type Self-Cooled, Three-Phase Distribution Transformers for use with Separable High-Voltage Connectors (High-Voltage 34500 Grd Y/19920 Volts and Below: 2500 kVA and Smaller)*

Part 3
SECONDARY NETWORK TRANSFORMERS

The American National Standard Requirements for Secondary Network Transformers, Subway and Vault Types (Liquid Immersed), C57.12.40-1990, (with the exception of paragraphs 5.5.4 and 11.5.2 on finishes) have been approved as NEMA Standards for secondary network transformers and should be inserted in this Part 3.

The following other parts of this NEMA Publication No. TR 1 shall also apply for secondary network transformers:

a. Part 0 General
b. Part 6 Terminology
c. Part 7 Test Code

Part 4
DRY-TYPE TRANSFORMERS

The following American National Standards have been approved as NEMA Standards for dry-type transformers and should be inserted in this Part 4:

ANSI/IEEE C57.12.01-1989	*General Requirements for Dry-type Distribution and Power Transformers*
ANSI/IEEE C57.12.91-1979	*Test Code for Dry-Type Distribution and Power Transformers*
ANSI C57.12.50-1989	*Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase; With High-Voltage 601-34500 Volts, Low-Voltage 120-600 Volts*
ANSI C57.12.51-1989	*Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase With High-Voltage 601-34500 Volts, Low-Voltage 208Y/120-4160 Volts*
ANSI C57.12.52-1989	*Requirements for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, With High-Voltage 601-34500 Volts, Low-Voltage 208Y/120-4160 Volts*
ANSI/IEEE C57.94-1982	*Recommended Practices for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers*
ANSI/IEEE C57.96-1989	*Guide for Loading Dry-Type Transformers, Appendix to C57.12 Standards*

Part 5
UNIT SUBSTATION TRANSFORMERS

The following other parts of this NEMA Publication No. TR 1 shall also apply for unit substation transformers.

a. Part 0 General
b. Part 6 Terminology
c. Part 7 Test Code

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Part 6
TERMINOLOGY

The ANSI/IEEE Standard C57.12.80-1992, has been approved as a NEMA Standard for terminology and should be inserted in this Part 6.

Part 7
TEST CODE

The American National Standard ANSI/IEEE C57.12.90-1987, has been approved as a NEMA Standard for transformer tests and should be inserted in this Part 7.

This NEMA standard, Part 7, shall also apply for transformer tests.

The ANSI/IEEE Standard C57.98-1992, should be inserted in this Part 7.

7.01 TEST CODE FOR MEASUREMENT OF RADIO INFLUENCE VOLTAGE LEVELS

a. Apparatus

The apparatus to be tested under this code can be divided into two general classes as follows:

Class 1— Potential-type transformer apparatus, such as transformers for step-up, step-down or interconnected service, and some arrangements of regulating transformers and autotransformers.

Class 2— Series-type transformer apparatus, such as series transformers, shunt (iron core) reactors, current-limiting reactors and some arrangements of regulating transformers and autotransformers.

b. Equipment

The equipment and general method used in determining the radio influence voltage shall be in accordance with the NEMA Standards Publication Methods of Measurement of Radio Influence Voltage (RIV) of High-voltage Apparatus, 107-1964 (R-1971, 1976, R-1992). For an alternate method, see par. E, Use of Bushing Capacitance Tap.

c. Connections for testing—Class A-1 Apparatus

The test voltage shall preferably be impressed across the winding under test (see Fig. 7-1). It may, however, be induced from a winding other than that being tested (see Fig. 7-2). In order that the results be comparable, the circuit arrangements and constants must be as shown in Fig. 7-1 or 7-2. The winding shall be tested first with one end grounded and then with the other end grounded.

The test on a reduced-voltage neutral terminal shall correspond to the insulation class of the neutral. Windings with one end solidly grounded obviously will receive no test on the grounded end.

One terminal of each winding not under test, the ground terminal if one is available, shall be connected to the tank and ground.

d. Connections for testing— Class A-2 Apparatus

The test voltage shall be applied to the winding under test, with all terminals of the winding under test tied together (see Fig. 7-3).

e. Use of bushing capacitance tap

If radio influence voltage is measured at the capacitance tap of the bushing, a suitable device shall be used which can be tuned with the bushing tap to ground capacitance at the measuring frequency. This device shall constitute all circuit elements from the capacitance tap of the bushing to the radio noise meter.

The coaxial cable, an element of the device, may be any suitable impedance and need not be terminated in its characteristic impedance. The purpose of the device is to minimize the dividing effect of the bushing capacitance and to convey the radio influence voltage to the radio noise meter with minimum attenuation. See Fig. 7-4 and 7-5.

f. Calibration for circuits using bushing capacitance tap

The calibration ratio will be determined by:

1. Applying to the terminal under test the output of a sine-wave signal generator at approximately 100 microvolts and at the measuring frequency, or that of a pulse signal generator at approximately 100 microvolts.
2. Measuring the voltage on the terminal with the radio noise meter connected directly to the terminal.
3. Measuring, with the same radio noise meter, the voltage appearing in the test circuit at the location where the radio noise meter will be connected during the radio influence voltage measurement on the transformer (a second radio noise meter shall be permitted to be used instead, provided its relationship to the first radio noise meter has been established).
4. It shall be established that this calibration ratio remains valid over the radio influence voltage range of interest.

The ratio of the voltage measured with the radio noise meter at the terminal to the voltage measured with the radio noise meter at the normal location in the circuit

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which has been selected for the corona test on the transformer will be applied as a correction factor to the radio influence voltage reading obtained during the corona test to determine the actual radio influence voltage at the terminal of the winding under test.

g. Test voltage

The test voltage shall be determined from the preferred nominal system voltage in accordance with 0.04 in Part 0, except that the test voltage shall not exceed 110 percent of the rated voltage of the winding on the highest tap connection.

h. Precautions in making tests

The following precautions should be observed in measuring the radio influence voltage. The apparatus should be:

1. Tested at approximately the same temperature as the room in which the tests are made
2. Located as to provide the outside clearances recommended.

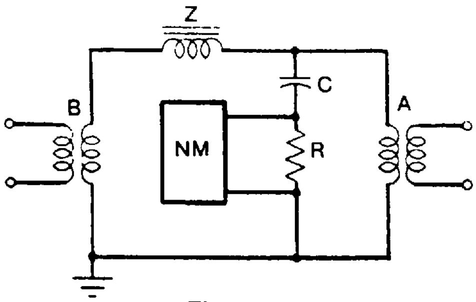

Fig. 7-1*

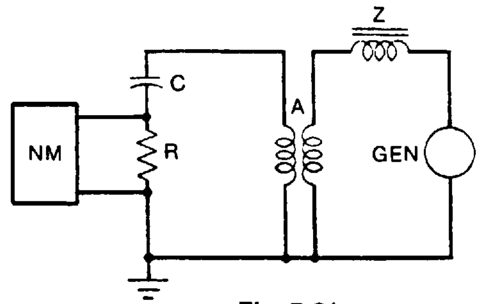

Fig. 7-2*

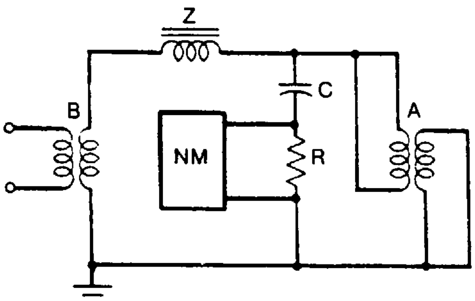

Fig. 7-3*

A -Transformer under test
B -Testing transformer
C -Coupling capacitor
NM-Radio noise meter
R -Terminating resistance
Z -Radio frequency choke

* Values for radio circuit elements and detailed connections shall conform to the NEMA Standards Publication *Methods of Measurement of Radio Influence Voltage (RIV) of High-voltage Apparatus*, 107-1964 (R 1971, 1976, R 1992).

TEST CIRCUITS FOR RADIO INFLUENCE MEASUREMENTS USING THE BUSHING CAPACITANCE TAP:

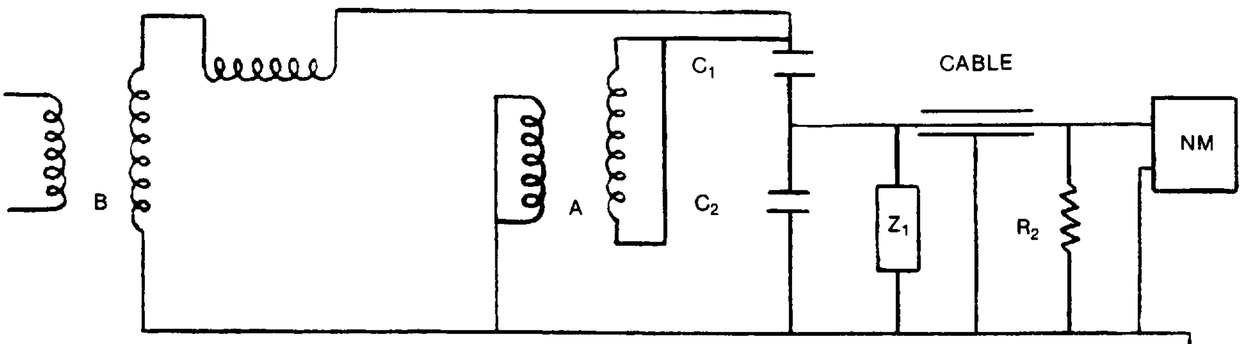

Fig. 7-4

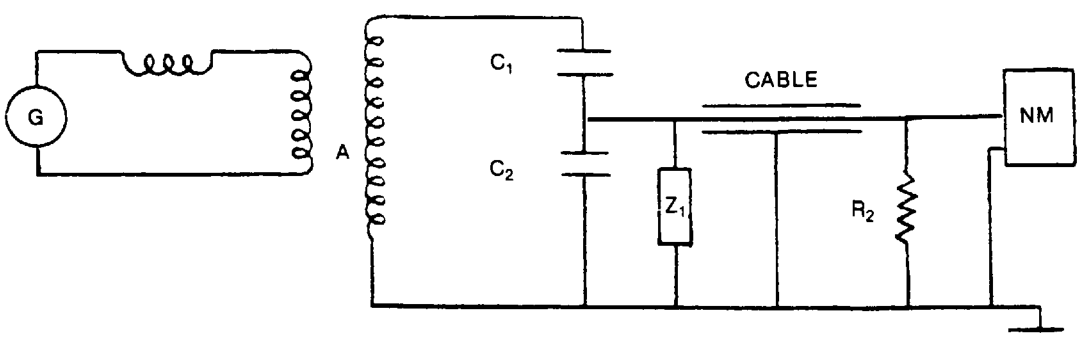

Fig. 7-5

A -Transformer under test
B -Testing transformer
C_1-High-voltage bushing capacitance
C_2-High-voltage bushing capacitance tap

CABLE-Shielded cable
Z_1 -Variable inductance
R_2 -Resistor
NM -Radio noise meter

7.02 TRANSFORMER TEST REPORT

To facilitate safe and effective operation of transformers it is recommended that the following information be included in the test report:

Manufacturer's Name ____________________

Purchaser ____________________

Date of Test __________ **Purchaser's Order No.** __________ **Mfr.'s Ref. No.** __________

Cooling Class __________ **Phase** ______ **Hertz** __________ **Insulating Fluid** __________

Winding (1) __________ **Volts** __________ **kVA** (2) __________ **Volts** __________ **kVA** (3) __________ **Volts** __________ **kVA**

Taps ____________________

RESISTANCE, EXCITING CURRENT, LOSSES AND IMPEDANCE—Based on normal rating unless otherwise stated. Losses and regulation are based on wattmeter measurements. For three-phase transformers the resistances given are the sum of the three phases in series.

Serial No.	Resistance in Ohms at 85°C			Exciting Current Percent at 100% Voltage	No Load Loss in Watts 100% Voltage	Watts Loss and Impedance at 85°C					
						______V to ______V ______kVA		______V to ______V ______kVA		______V to ______V ______kVA	
	(1)	(2)	(3)			Load Loss	% Imp.	Load Loss	% Imp.	Load Loss	% Imp.
						Total Loss		Total Loss		Total Loss	
Average											
Guarantee											

TEMPERATURE RISES are in degrees C corrected to instant shutdown.

Serial No ____________________ with windings connected and loaded as follows:

Multi-winding transformer heat run connections for the determination of the maximum winding rises over ambient may not be the same as that for the maximum losses which produce the maximum fluid rise. Such temperature rise entries shall be on separate lines in the Temperature Rise table of the Test Report Form. Precautions should be taken to assure that the fluid temperature rise and winding rises entered on a common line correspond to the same test conditions.

Cool Mode	Temp. Rise Guar. °C	Fluid R. Above Amb.			Winding Differential Above Average Fluid								
					Energized Winding			Shorted Winding			Rise by Res. °C		
		Losses Dissipated	Top °C	Ave. °C		Tap-kV	Amps		Tap-kV	Amps	(1)	(2)	(3)

DIELECTRIC TESTS—If Impulse Tests are required, see separate Transformer Impulse Test Report.

APPLIED POTENTIAL TESTS Voltage applied between each winding and all other windings connected to core and ground.	Voltage Rating of Winding Tested	Test Voltage Applied	Duration of Test in Seconds
INDUCED POTENTIAL TESTS	______ hertz for ______ cycles	______ times rated voltage across full winding ______ kV from ______ kV line terminal to ground	

REMARKS:

I hereby certify this is a true report based on factory tests made in accordance with the Transformer Test Code C57.12.90 current edition of the American National Standards Institute, and that each Transformer withstood the above insulation tests.

Signed ____________________ Date ____________________ Approved by ____________________
Transformer Engineering Dept.

Authorized Engineering Information 11-20-1980.

7.03 TRANSFORMER IMPULSE TEST REPORT

To facilitate safe and effective operation of transformers it is recommended that the following information be included in the test report:

Manufacturer's Name ________________________________

Purchaser ________________________________

Date of Test ____________ Purchaser's Order No. ____________ Mfr.'s References ____________

Type ____________ Phase ____________ Cycles ____________ Insulating Fluid ____________

H-winding ____________ Volts X-winding ____________ Volts Y-winding ____________ Volts

Serial No.	Oscillograms	Test*	Surge Applied on Terminal No.	kV Required	kV Applied	Microsecond to Crest	Microsecond to Flashover

*RFW-Reduced Full Wave *CW-Chopped Wave *FW-Full Wave

REMARKS:

Signed ____________________ Date ____________ Approved ____________________
Transformer Engineering Dept.

Page ____________ of ____________ Pages

7.04 REACTOR TEST REPORT

To facilitate safe and effective operation of transformers it is recommended that the following information be included in the test report:

Manufacturer's Name ______________________________

Purchaser ______________________________

Date of Tests __________ **Purchaser's Order No.** __________ **Mfr.'s Ref. No.** __________

Type __________ **Phase** __________ **Cycles** __________ **Insulating Fluid** __________

Volts Drop __________ **kVA** __________ **Amperes** __________

For connection in ______________________ **Volt Circuit** __________

RESISTANCES, LOSSES AND IMPEDANCE are based on normal rating, unless otherwise stated. Losses are based on wattmeter measurements.

Serial No.	Resistance at 85 °C			Total Loss Watts 85 °C	Impedance	
	Phase A	Phase B	Phase C		Volts	%
Average						
Guarantee						

TEMPERATURE RISE in degrees C corrected to instant of shutdown.

Serial No.	Amperes	Rise by Resistance	Guarantee

INSULATION TESTS—high-potential tests were made on each reactor. Voltage was applied between winding and ground and between phases of a polyphase reactor. Voltage at high frequency was induced in each winding to test the turn-to-turn strength.

Voltage Rating of Winding	Applied Voltage at Normal Frequency	Induced Voltage at High Frequency

REMARKS:

Signed ______________ **Date** __________ **Approved** ______________

Part 8
TRANSMISSION AND DISTRIBUTION VOLTAGE REGULATORS

The ANSI/IEEE Standard C57.15-1992, has been approved as NEMA Standards for transmission and distribution voltage regulators and should be inserted in this Part 8.

The ANSI/IEEE Stanard C57.95-1992. Appendix to C57.15, has been approved as NEMA Standard for Transmission and distribution voltage regulators and should be inserted in this Part 8.

Part 9
CURRENT-LIMITING REACTORS

[To Be Published]

Part 10
ARC FURNACE TRANSFORMERS

The following other parts of this NEMA Publication No. TR 1 shall also apply for arc furnace transformers:

a. Part 0 General
b. Part 6 Terminology
c. Part 7 Test Code

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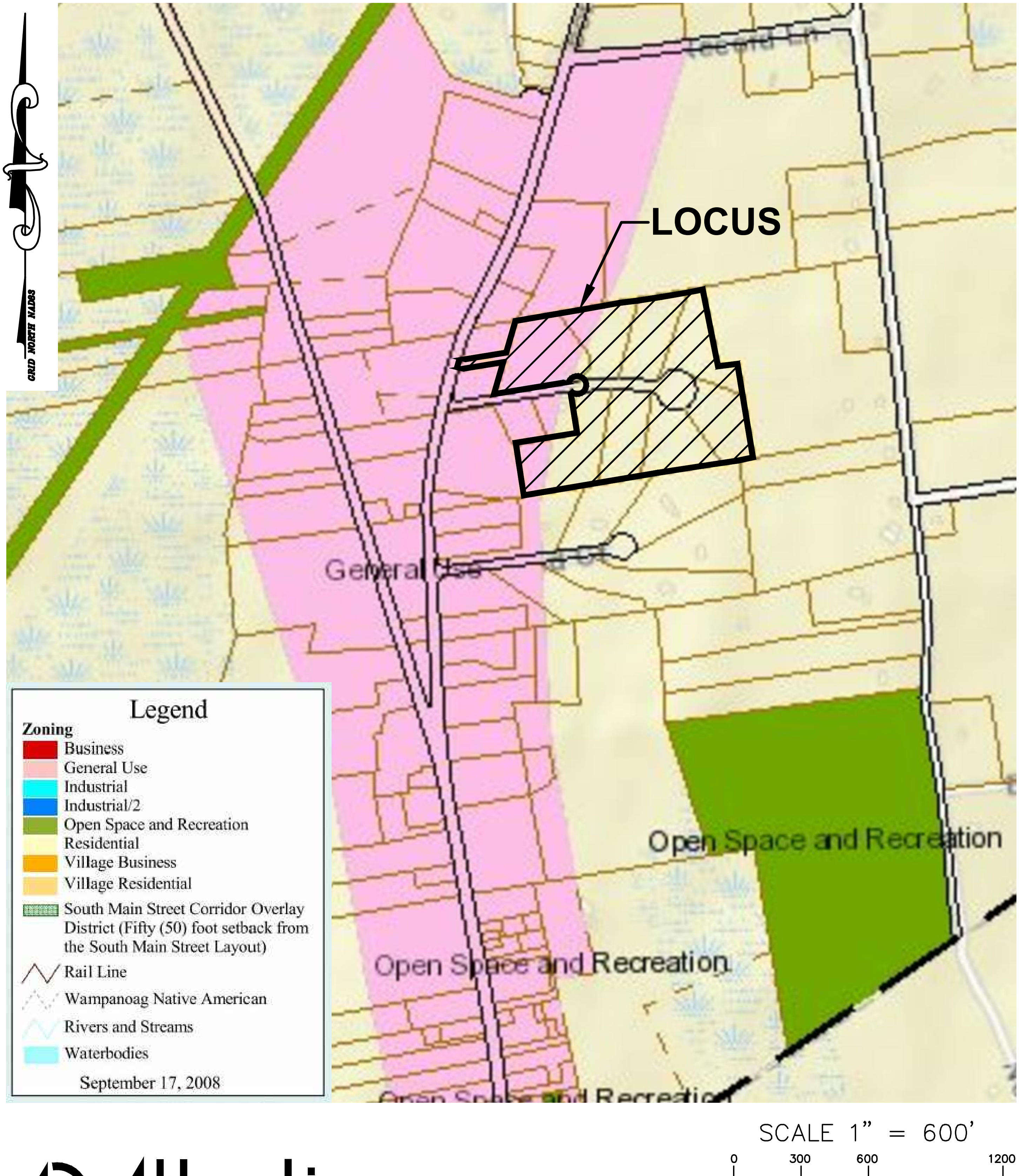
Part 11
SHUNT REACTORS

The American National Standard, C57.21-1991, has been approved by NEMA and should be inserted in this Part 11.

ZONING FIGURE



Atlantic® DESIGN ENGINEERS, INC
P.O. Box 1051, Sandwich, MA 02563 (508) 888 – 9282

FILE: 3220.01–FIGURES

APPLICANT:
CVE NORTH AMERICA, INC.
109 W 27TH STREET, 8TH FLOOR
NEW YORK, NY 10001

FIGURE – ZONING MAP
FOR
MIDDLEBORO ROAD SOLAR PROJECT
FREETOWN, MASSACHUSETTS 02717
MARCH 12, 2021

Sheet 1 of 1
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