

Quarterly Interim Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment

Citation of Law or Resolution: Section 2.(d) of S.L. 2019-132 (H329)
Due Date: Quarterly
Submission Date: December 1, 2019

Receiving Entities:

The Environmental Review Commission
The General Assembly

Submitting Entity:

Department of Environmental Quality

Quarterly Interim Report of the Department of Environmental Quality

Executive Summary and Transmittal

Pursuant to Section 2.(d) of S.L. 2019-132 (H329/Renewable Energy Amends), the North Carolina Department of Environmental Quality (Department or DEQ) and the Environmental Management Commission (Commission), must submit quarterly interim reports as to the activities conducted, including updates on the stakeholder process and the work to adopt rules governing the management of end-of-life photovoltaic modules and energy storage battery systems and the decommissioning of utility-scale solar projects and wind energy facilities, to the Environmental Review Commission and the General Assembly. This is the first quarterly interim report that covers the activities undertaken to implement this Section from July 19, 2019 (the effective date of the Act), through November 15, 2019.

Quarterly Interim Report of Activities

In accordance with Section 2.(c) of S.L. 2019-132, the Department established a stakeholder process and convened its first meeting on Friday, September 13, 2019. The agendas for the September and November stakeholder meetings are included as Appendix A to this report. To follow is a brief summary of the work undertaken to date by the Department and the stakeholders to implement this Section of the Act. Thus far, the work to implement this Section of the Act has been done exclusively by DEQ and the stakeholders, and reviewed by the Commission.

DEQ Resources

Due to the multi-disciplinary scope of the legislative directive to adopt rules governing the management of end-of-life photovoltaic (PV) modules and energy storage battery systems and the decommissioning of utility-scale solar projects and wind energy facilities, staff from three DEQ units are assigned to support this effort. The Division of Waste Management, the Division of Environmental Assistance and Customer Service, and the State Energy Office are each represented and this team's work is coordinated by the Office of Governmental Affairs and Policy.

Stakeholder Organizations¹

The following public, private, and not-for-profit organizations were invited to participate in the stakeholder process required by Section 2.(c) of S.L. 2019-132. In addition to these entities, DEQ solicited stakeholder's feedback to broaden and include participation from all potentially interested parties.

Duke Energy*	Synergy Recycling
Dominion Energy*	Metech Recycling
NC Electric Membership Cooperatives*	GEEP Global (Global Electric Electronic Processing)
NC Sustainable Energy Association*	Powerhouse Recycling Inc.*
First Solar*	Institute of Scrap Recycling Industries, Inc.*
Cypress Creek Renewables*	Carolina Recycling Association
NC Clean Energy Business Alliance	Dynamic Lifecycle Innovations*
NC Farm Bureau*	eCycleSecure
Energy & Environment Innovation Foundation	ERI
Ecoplexus	TT&E Iron and Metal
Smith Gardner Inc.	Foils Inc.
Sierra Club*	Regional Materials Recovery, Inc.
NC Conservation Network*	NC Utilities Commission-Public Staff
Southern Environmental Law Center*	Advanced Energy*
Recycling Association of NC	NC Department of Public Safety*
NC Clean Energy Technology Center*	NC Association of County Commissioners*
Solar Energy Industries Association*	Alamance County
NC State University Extension	

¹ Organizations with an asterisk (*) have participated in the stakeholder meetings either in-person or by remote conference call.

Matters Under Consideration

Pursuant to Section 2.(a), DEQ must consider nine matters in its development of the rules governing the management of end-of-life PV modules and energy storage battery systems and the decommissioning of utility-scale solar projects and wind energy facilities. With assistance from stakeholders, DEQ has considered the following matters in the time captured by this interim report:

Section 2.(a)(1): Whether or not any PV modules, energy storage system batteries, or the constituent materials thereof, or other equipment used in utility-scale solar projects or wind energy facilities, exhibit any of the characteristics of hazardous waste identified in 40 C.F.R. Part 261, or under rules adopted pursuant to G.S. 130A-294(c), or whether or not any such equipment is properly characterized as solid waste under State and federal law.

Section 2.(a)(4): The data-based expected economically productive life cycle of various types of PV modules, wind turbines, and energy storage system batteries currently in use in the State.

Section 2.(a)(5): The volume of PV modules, wind turbines, and energy storage system batteries currently in use in the State, and projections, based upon the data on life cycle identified in subdivision (2) of this section, on impacts that may be expected to the State's landfill capacity if landfill disposal is permitted for such equipment at end-of-life.

Section 2.(a)(6): A survey of federal and other states' and countries' regulatory requirements relating to (i) management of end-of-life PV modules, energy storage system batteries, and other equipment used in utility-scale solar projects and wind energy projects, including identification of states' laws governing reuse, refurbishment, disposal, or recycling of such equipment, (ii) decommissioning of utility-scale solar projects and wind energy facilities, and (iii) financial assurance to be established by owners or operators of utility-scale solar projects and wind energy facilities to ensure responsible decommissioning.

Section 2.(a)(7): Whether or not adequate financial assurance requirements are necessary to ensure proper decommissioning of utility-scale solar projects upon cessation of operations.

Materials Received from Stakeholders To-Date

To support the scope of work, DEQ solicited assistance from the stakeholders to fill knowledge and data gaps. DEQ has received the following to-date:

- Dominion Energy provided a list of operational solar non-utility generators in its North Carolina service territory as of November 12, 2019, and a list of operational solar facilities in North Carolina as of November 14, 2019.
- Duke Energy submitted several interconnection queue snapshots as of October 22, 2019, a model decommissioning plan, a battery energy storage system recycling and disposal investigative report, and a paper on Duke Energy's current decommissioning perspective for utility-scale solar, wind, and energy storage facilities.
- Ecoplexus, Inc. shared decommissioning costs for two projects.
- First Solar shared a report on the cost of decommissioning utility-scale PV facilities, end-of-life heavy metal releases from PV modules, leaching tests with thin film solar cells, a

standardized toxicity characteristic leaching procedure (TCLP) sample extraction procedure, and an assessment of leaching tests for evaluating potential environmental impacts. First Solar also shared several reports about recycling and decommissioning utility-scale solar PV systems.

- The NC Clean Energy Tech Center (NCCETC) submitted a solar decommissioning map, a list of states with decommissioning requirements, a summary of solid and hazardous waste characteristics of various types of energy equipment, and information on financial assurances to ensure proper decommissioning. Simon Sandler, an Engineer with NCCETC presented at the November 15, 2019 stakeholder meeting on solar equipment and battery waste classification.
- NC Electric Membership Cooperatives (NCEMC) shared a list of utility-scale solar projects in the Cooperatives' service area and draft agreement language to address the responsibilities between tenants and landlords pertaining to decommissioning of solar projects.
- NC Sustainable Energy Association (NCSEA) provided reports on energy storage corporate responsibility initiatives, overview of PV module end-of-life management, health and safety impacts of solar PV, an overview of solar/wind decommissioning requirements in NC counties, and an example application for a certificate authorizing construction of a PV facility.
- Solar Energy Industries Association (SEIA) submitted decommissioning information for local governments in New York, and PV end-of-life management presentations.
- Southern Environmental Law Center (SELC) provided examples of international decommissioning regulations and an overview of solar, wind, and battery regulations in each state.
- Synergy Electronics Recycling shared papers regarding the end-of-life heavy metal releases, leaching of cadmium and tellurium from thin film solar panels, and current trends in recycling PV solar cells.

Upcoming Activities

DEQ will convene the next stakeholder meeting on Monday December 9, 2019, in Raleigh to discuss current practices for reuse/recycling of solar PV equipment, industry projections for reuse/recycling of solar PV equipment, and further discussion of decommissioning and financial assurance requirements.

DEQ anticipates convening monthly stakeholder meetings through 2020, as needed, to inform the Department's work to develop rules to govern the management of end-of-life photovoltaic modules and energy storage battery systems and the decommissioning of utility-scale solar projects and wind energy facilities. The Department has also convened a separate sub-stakeholder group to focus on financial assurance and decommissioning.

The next quarterly interim report will be submitted on or before April 1, 2020, and will include recommendations regarding the resources necessary to implement the requirements of the Act.

APPENDIX A
Stakeholder Meeting Agendas

Decommissioning Renewable Energy Equipment Stakeholders
(Per §2 of S.L. 2019-132/H329)
Introductory Meeting

Friday, September 13, 2019
10:00 a.m. to 12:00 noon
Ground Floor Hearing Room – Archdale Building
512 N. Salisbury Street, Raleigh NC

Remote Dial-In Number: (605) 472-5547 / Passcode: 639818

AGENDA

1. Welcome and introductions
2. DEQ's interagency role and Agency organizational approach
3. Legislative charge to DEQ and the Stakeholders
4. Proposed timeline to meet directives set out in §2 of S.L. 2019-132
5. What do we know and what information gaps need to be filled?
6. Discussion of proposed schedule of stakeholder meetings
7. Adjourn

Decommissioning Renewable Energy Equipment Stakeholders (Per §2 of S.L. 2019-132/H329)

Friday, November 15, 2019

10:00 a.m. to 12:00 noon

Wake Tech Community College, Western Wake Campus, Room 101

3434 Kildaire Farm Road, Cary NC 27518

Remote Dial-In Number: (919) 850-2822 (No Passcode is Required)

AGENDA

1. Welcome and introductions
2. Presentations²
 - a. Review of data and information provided to date
 - b. Overview of end-of-life management of PV modules in other jurisdictions
Katie Wanka, Environmental Program Consultant
Division of Waste Management (DWM), Department of Environmental Quality (DEQ)
 - c. Overview of utility-scale solar PV project decommissioning requirements, including financial assurance, in NC and other jurisdictions
Jessica Citroia, Environmental Specialist II
DWM, DEQ

Stakeholders discussion of financial assurance requirements for utility-scale solar projects
3. Overview and discussion of solid and hazardous waste characteristics of equipment used in utility-scale solar projects and energy storage system batteries and whether these meet the statutory definition of hazardous waste
Simon Sandler, Clean Power & Industrial Efficiency Project Engineer
NC Clean Energy Technology Center
4. Discuss knowledge gaps and assign homework
 - a. Discussion of who the regulated entity would be (e.g., developers, utilities, solar farm operators, landowners, commercial entities, municipalities)
 - b. Calculating net salvage value (NSV) of decommissioned renewable energy equipment
 - c. Applying NSV to decommissioning requirements
 - d. Information needed to provide certainty to grow recycling industry?
5. Discuss topics for next stakeholders meeting
6. Adjourn

Next Meeting:

Monday, December 9, 2019

1pm to 3pm

Ground Floor Hearing Room

512 N. Salisbury Street, Raleigh NC

² Presentations are included in Appendix B.



Decommissioning of Renewable Energy Equipment

Stakeholders Meeting
November 15, 2019



Information Recap

To date, information has been received by the following entities:

- Duke Energy
- First Solar
- NC Clean Energy Technology Center
- NC EMC
- NCSEA
- SEIA
- SELC
- Synergy Recycling

SharePoint Site: <https://ncconnect.sharepoint.com/sites/edswess>

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Data Received to Date

- Interconnection Data
- Model Decommissioning Plans and Examples of Agreement Language
- Studies on Salvage Values and Costs of Decommissioning of Solar Projects
- Solid Waste Resulting from Decommissioning of Power Plants
- Reports on End-of-Life Management of PV Modules
- PV Module Recycling Technologies
- Studies on Hazardous Materials in Various Types of PV Modules
- Summary of NC Counties and State Decommissioning Requirements
- Report on Battery Recycling and Disposal

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3



End-of-life Management of PV Modules in Other Jurisdictions

Stakeholders Meeting
November 15, 2019



State End-of-Life PV Policies

Washington Photovoltaic Module Stewardship and Takeback Program (Rev. Code of WA § 70.355.010)

Effective January 1, 2021, manufacturers selling within the state are required to finance the takeback and recycling system at no cost to the owner of the PV modules. A product stewardship organization may act on behalf of the manufacturers to operate and implement the stewardship program.

Washington Department of Ecology is responsible for developing guidance for manufacturers and to ensure that the takeback plan offers a convenient collection system, and that the takeback and recycling of the modules is done in a safe and environmentally sound matter.

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State End-of-Life PV Policies

California Universal Waste Management Regulations (CA Health & Safety Code § 25259)

Department of Toxic Substances Control has been authorized to adopt regulations to designate end-of-life PV modules, identified as hazardous waste, as an universal waste.

As of April 2019, the Department is working on the rulemaking package and has not yet begun the formal rulemaking process.

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State End-of-Life PV Policies

New Jersey Solar Recycling Commission (N.J. Stat § 13:1E-229)

The purpose of the Commission is to investigate options for recycling and other end-of-life management methods for PV and other solar energy generation structures, and to develop recommendations for legislative, administrative, or private sector action. This bill was enacted on August 9, 2019.

The Commission has one year, from appointment of members, to submit a report with their findings. This deadline may be extended an additional year upon notice to the Governor and the Legislature.

The act also authorizes the N.J. Department of Environmental Protection to adopt rules and regulations based on the Commission's final report.

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State End-of-Life PV Policies

Hawaii (HR 126 of 2019)

Requests the Hawaii State Energy Office perform a study on the feasibility of incentivizing the creation of a glass and solar panel recycling plant using funds from a fee to be attached to each solar panel sold in the state.

The report is due to the Legislature prior to the convening of the Regular Session of 2020.

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International Policy

European Union - Waste Electrical and Electronic Equipment Directive (WEEE Directive 2012/19/EU)

As of 2014, the WEEE Directive requires all producers supplying PV modules to the EU market to finance the costs of collecting and recycling end-of-life modules.

The Directive includes requirements for labeling of the panels, providing information to waste handlers on the specifics of hazardous waste content, and collection and recycling targets.

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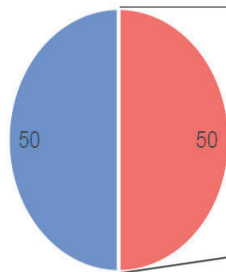
Utility-Scale Solar PV Project Decommissioning Requirements

Stakeholders Meeting
November 15, 2019



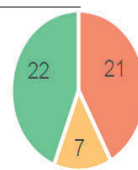
North Carolina County Ordinances

NC Counties with Decommissioning Regulations for Solar Facilities



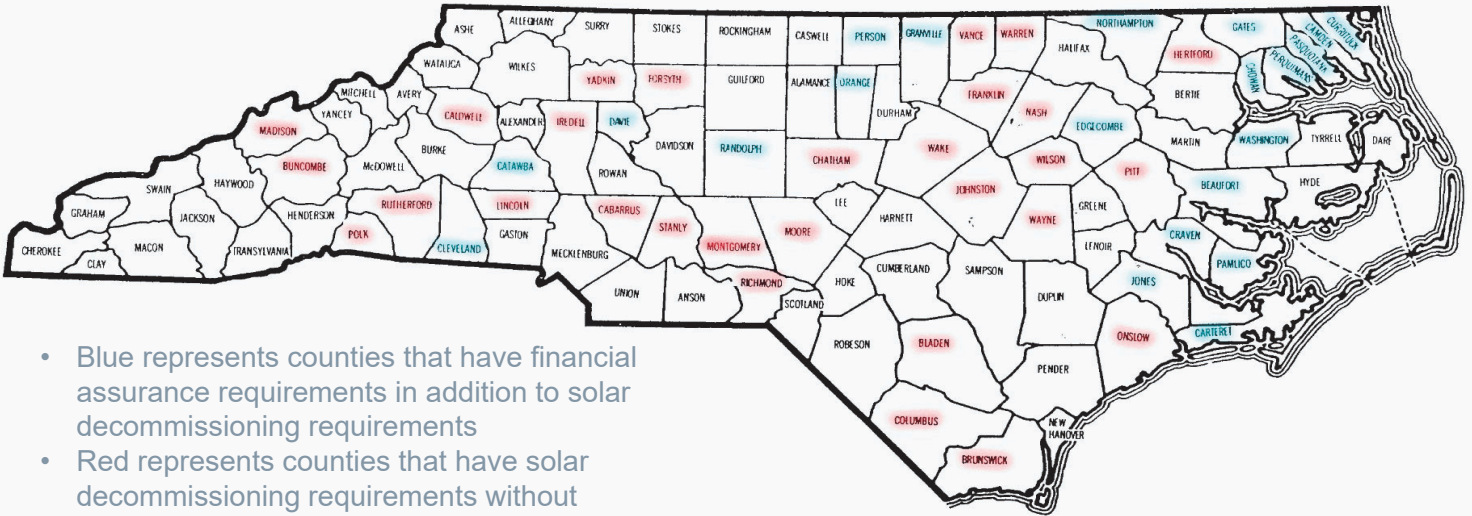
- Counties without solar decommissioning regulations
- Counties with solar decommissioning regulations

NC Counties with Financial Assurance Requirements for Solar Facilities



- Counties with solar financial assurance requirements
- Counties considering decommissioning costs without financial guarantee requirement
- Counties without solar financial assurance requirements

North Carolina County Ordinances



- Blue represents counties that have financial assurance requirements in addition to solar decommissioning requirements
- Red represents counties that have solar decommissioning requirements without financial assurance

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North Carolina County Requirements

- A typical NC county decommissioning plan requires the site to be decommissioned after a certain period, and usually involves the removal of all solar equipment and restoration of the entire property.
 - County governments require decommissioning a solar facility typically after no electricity is produced or after cessation of operations for a continuous period.
- Many counties require the solar facility decommissioning plans to include a decommissioning timeline, estimated decommissioning costs, anticipated methods for decommissioning, and plans for updating decommissioning plan in the future.
 - Some counties specify that the decommissioning costs need to be estimated by a third-party licensed engineer.

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North Carolina County Requirements

- Most of the counties that have financial assurance measures for solar decommissioning require a type of financial guarantee greater than or equal to the estimated decommissioning costs, with the estimated decommissioning costs to be re-evaluated on a regular basis.
- Few counties allow consideration of the potential salvage value in the estimated decommissioning costs for financial assurance.
- The highest financial assurance requirement for a North Carolina county is 125 percent of the estimated decommissioning cost.
- Types of financial assurance used in North Carolina counties include a surety bond, certified check, irrevocable letter of credit, and a cash escrow.

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15

Other States' Requirements

- California
- **Hawaii**
- Maine
- Minnesota
- **Montana**
- **New Hampshire**
- New Jersey
- **North Dakota** (proposed rule)
- Ohio (No decommissioning plan, but FA may be required)
- South Dakota
- **Vermont**
- **Virginia**
- Washington (FA only for projects that obtain certification from the Energy Facility Site Evaluation Council)

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16

Other States' Requirements

- 13 states have implemented solar PV decommissioning as a statewide requirement.
- In general, utility-scale solar PV decommissioning requirements varied between states.
- For several states, utility-scale solar PV projects require a decommissioning plan as a part of an application, easement, permit, or certificate required prior to construction or operation.
- Financial assurance measures require a form of proof of financial security.

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17

Other States' Requirements - Maine

- Maine: 01-672 Me. Code R. Ch. 10, Such. II, §§ 10.21(2)(d), (3)(d)
 - Solar energy generation facilities are categorized within commercial industrial development (D-CI) sub-districts as special exceptions under issuance of a permit from the Commission.
 - The applicant is required to provide substantial evidence that upon decommissioning of the facility all structures and materials associated with the development will be removed, and affected soils will be replaced or restored to a state such that they could be used for active agricultural production.

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18

Other States' Requirements- New Hampshire

- New Hampshire- Title XII, Chapter 162, Section H:7
 - Renewable energy facilities greater than or equal to 5 MW require a certificate from the Public Utilities Commission.
 - The application for the certificate requires a description of the decommissioning plan and financial assurances for decommissioning.

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19

Other States' Requirements- Virginia

- Virginia - Code of Virginia, § 15.2-2241.2
 - Requires a locality, as part of the local legislative approval process or as a condition of approval of a site plan to require an owner, lessee, or developer of real property to enter into a written agreement to decommission solar energy equipment, facilities, or devices upon certain terms and conditions, including financial assurance.
 - Financial assurance should be in the form of certified funds, cash escrow, bond, letter of credit, or parent guarantee.
 - The estimate shall not exceed the total of the projected cost of decommissioning, which may include the salvage value of such equipment, facilities, or devices, plus a reasonable allowance for estimated administrative costs related to a default of the responsible party, and an annual inflation factor.

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20

States with Model Ordinances

The following states do not have statewide requirements but provide guidance for utility-scale solar decommissioning to local governments in the form of a model ordinance:

- North Carolina,
- Georgia,
- Massachusetts,
- New York, and
- Rhode Island.

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21

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22

Thank you!

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HB 329: Solar & Storage Waste Classification Overview

NC Clean Energy Technology Center
Simon Sandler, Project Engineer
Friday, November 15th



Mission Statement

The N.C. Clean Energy Technology Center, at N.C. State University, advances a sustainable energy economy by educating, demonstrating, and providing support for clean energy technologies, practices, and policies.

The Center provides services to the businesses and citizens of North Carolina and beyond relating to the development and adoption of clean energy technologies. For the last 30 years, the Center has worked closely with partners in government, industry, academia, and the non-profit community.



Programs

- Renewable Energy
- Clean Power and Industrial Efficiency
- Training
- Clean Transportation
- Policy and DSIRE Insight



HB 329 – Section 2.(a)

(1) Whether or not any photovoltaic modules, energy storage system batteries, or the constituent materials thereof, or other equipment used in utility-scale solar projects or wind energy facilities, exhibit any of the characteristics of **hazardous waste** identified in 40 C.F.R. Part 261, or under rules adopted pursuant to G.S. 130A-294(c), or whether or not any such equipment is properly characterized as **solid waste** under State and federal law.

Defining Hazardous

Title 40 of the Code of Federal Regulations (C.F.R.)

- Chapter 1, Subchapter 1, Part 261, Subpart C
- “Characteristics of Hazardous Waste”
 - Ignitable: Causes fire via friction, moisture absorption, spontaneous chemical change [ex. Waste oils]
 - Corrosive: Applies to aqueous and liquids [ex. Battery acid]
 - Reactive: Unstable, reacts with water, toxic fumes, explosive, etc... [ex. Lithium sulfur battery]
 - Toxic: Per TCLP if the leachate concentration of the listed contaminants is above acceptable levels [ex. Mercury, lead]
 - TCPL - Toxicity Characteristic Leaching Procedure



Defining Hazardous

General Assembly General Statutes

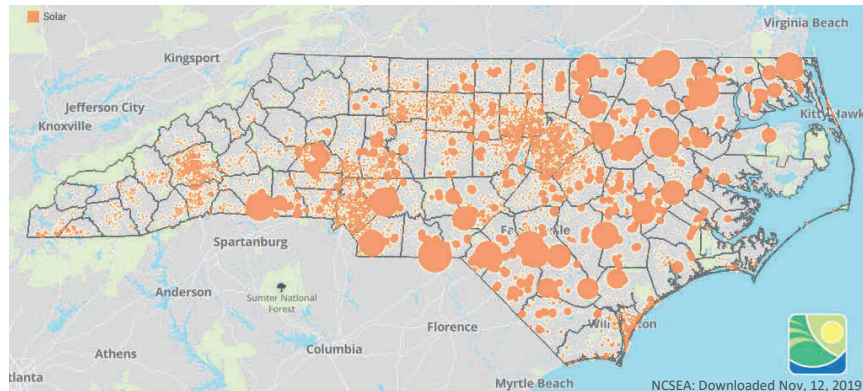
- Chapter 130A, Article 9 (Solid Waste Management), 294 – Solid Waste Management Programs
 - (c)1 & (c)1a : Establish criteria for hazardous waste and their constituents

NC Administrative Code

- Title 15A (Environmental Quality) Chapter 13A
 - 106 – “IDENTIFICATION AND LISTING OF HAZARDOUS WASTES - PART 261”
 - (c): **Adopts 40 C.F.R. with no alterations**



PV Solar Systems



- Components
 - Solar modules (panels)
 - Inverters & Transformers
 - Mounting & Racking/connection hardware
 - Site: concrete, gravel, fencing, conduit...



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PV Modules

- Module Chemistries
 - Crystalline Silicon (c-Si): >90% of market
 - Thin Film (CdTe, CIGS, etc.): ~7% of market (CdTe>CIGS)
 - Others (<1% of market): concentrating, organic, heavy metals...
- Hazardous constituent material & toxic concentration levels
 - Lead: 5mg/L
 - Cadmium: 1mg/L
 - Silver: 5mg/L
 - Selenium: 1mg/L



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Module Toxicity Testing & Findings

- EPA Toxicity Characteristic Leaching Procedure (TCLP)
 - module assembly broken into small pieces
 - held in an acid bath for a designated time
 - leachate is tested for toxic substances
- Lead
 - Only present in some solder
 - When present leachate concentration <5mg/L
 - Functionally, panel construction limits Lead release
- Cadmium
 - Present in stable/less toxic form as Cadmium Telluride



State Regulations

(2017) Washington State: PV Module Stewardship and Takeback Program

- Manufacturers selling solar modules in the state after July 1, 2017 are held responsible for the creation, financing, and implementation of a collection system and reuse and recycling plan at no cost to the system owner.

(August, 2019) New Jersey SB 601

- This Bill established the New Jersey Solar Panel Recycling Commission to develop recommendations and report recycling and end-of-life management options for the state.

(2015-Currently Modifying) California

- Formerly classified as Hazardous Waste, the California Department of Toxic Substances Control (DTSC) is now in the process of classifying PV modules as Universal Waste. This less stringent requirement would make PV waste easier to collect, transport, and recycle.



Remaining System Components

- Transformers: Use non-toxic mineral or vegetable oil
 - Old models contained PCBs
 - service equipment contamination should be avoided
- Mounting & Racking: Steel & Aluminum (anti-corrosive)
 - Non-hazardous
 - Recyclable: substantial portion of the facilities decommissioning value
- Site materials: concrete, gravel, fencing, etc.
 - Disposal should be as solid waste in appropriate landfills (or reuse/recycled)



Remaining System Components Cont.

- Electric Components – inverters, wiring, etc.
 - The electrical components including the inverter are not listed as electronic waste that cannot be landfilled
 - Per NCGS 130A-309.130 through 130A-309.142
 - Bans televisions, computers, monitors, printers, scanners, scanner-fax machines
 - They are comprised of similar components to other common place electronics
 - Many inverters are Rohs compliant (to be sold in Europe)
 - Restriction of Hazardous Substances (Rohs) covers lead, mercury, cadmium, and other toxic materials



Conclusions & Ongoing Questions

- All current components of a solar system are classified as non-hazardous under current federal (and State) regulations
- PFAS: Per- and polyfluoroalkyl substances
 - Media reports have speculated about water contamination from solar panels
 - NC Clean Tech Center pursuing funding to research topic
- Future new/modified module chemistry
 - advanced c-Si and CdTe thin film projected to continue to dominate markets



Battery Systems



- Components
 - Cells & Wiring
 - Cooling
 - Fire suppressant
 - Housing, racking, & support (concrete pad, gravel, etc.)



Battery Chemistry

- Lithium-Ion (Li-ion, vary by manufacturer)
 - High energy density, high cost, better for low depth of discharge (DoD), dominates current stationary storage market
- Lead acid (PbA)
 - Seen mainly at residential and not commercial scale, low energy density, low cost, contains toxic lead, high recycling rate
- Nickel-based (Ni-Cd, Ni-MH)
 - Some contain cadmium (toxic), high cost, high self-discharge rate, higher energy density than lead acid, early adoption that has faded
- Sodium-based (NaS)
 - Higher energy density, high operation temperature present risk operation complications, good DoD, non toxic, reactive and explosive with air

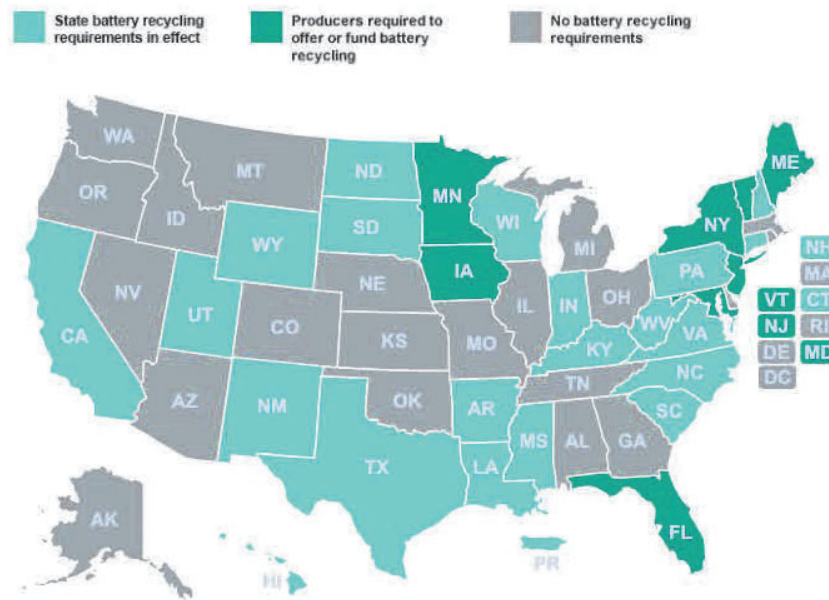


Hazardous Classification

- Batteries could fall under any of the four hazardous classifiers
- Lead acid batteries are Universal Waste (hazardous with special regulations to allow for recycling)
- Most other batteries are not specifically called out as hazardous waste, but many could qualify given their constituent chemicals, reactivity, corrosive components, or even ignitability
 - If classified as universal waste, could be recycled more easily through collection and storage of large quantities



Regulations



Conclusions & Ongoing Questions

- There is lacking data and information out there to corroborate the waste classification of many battery chemistries
 - Are utility scale batteries classified differently than consumer electronics because of scale? (universal/hazardous/solid)
 - Further discussion with WM would be highly beneficial
- There have already been complications with residential incorrect disposal of batteries (Lithium Ion specifically)
- Look to Lead acid for a system and mechanism for collection
 - Lead acid batteries are highly recyclable, not all chemistries are

Some Resources

- NCCETC - Health and Safety Impacts of Solar Photovoltaics [White Paper](#), 2017
- IES PVPS Task 12 (2018) - [End-of-Life Management of Photovoltaic Panels: Trends in PV Module Recycling Technologies](#)
- IRENA & IEA PVPS (2016) – [End of life management: Solar Photovoltaic Panels](#)
- EPA – [RCRA User Manual](#) (2014)



Thanks

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