EPRI

TECHNICAL BRIEF

# Utility-Scale Solar PV Decommissioning FAQ

## What Is Solar PV Decommissioning and Why Is It Important?

### KEY TAKEAWAYS

While there is limited experience decommissioning PV facilities, regulations to manage this practice are emerging, primarily at the state and local level, although some federal agencies such as the Bureau of Land Management (BLM) have decommissioning policies as well. Insights on decommissioning practices and policies can support PV asset owners, utilities, and their customers plan for end-of-life (EOL) management of PV systems. This research indicated several key takeaways:

- Decommissioning regulations are emerging, primarily at the state and local level. The BLM and 29 U.S. states have decommissioning policies that may apply to utility-scale PV systems.
- BLM and 23 of the 29 U.S. states with solar decommissioning policies require a solar developer to submit a decommissioning plan to the federal, state, and/or local regulatory authority with jurisdiction.
- Decommissioning plan requirements vary across jurisdictions but often require details about the system's lifespan, a site reclamation/restoration plan, plans for transportation/salvage/disposal of equipment and infrastructure, cost estimates for decommissioning, descriptions of potential impacts on natural resources, and estimated timelines.
- BLM and 22 of the 29 U.S. states with solar decommissioning policies require a solar developer to provide proof of financial assurance to the federal, state, and/or local regulatory authority with jurisdiction.
- Financial assurance may be required upfront or during operation, and may include surety bonds, trusts, or guarantees.
- Depending on the age and condition of PV modules at the time of decommissioning, disposition options may include repair, reuse through donation or resale, long-term storage, recycling, or landfill disposal.
- Per the EPA, PV modules taken out of service for EoL management are categorized as general waste and are subject to a hazardous waste determination under the Resource Conservation and Recovery Act (RCRA). The requirements/restrictions that apply to asset owners, handlers, transporters, and recyclers of EoL PV modules vary by state.

Utility-scale solar photovoltaic (PV) development is projected to increase in the United States as domestic renewable energy demand grows and the cost of solar PV energy decreases. To ensure sustainable development practices, it is important to consider the entire life cycle of the PV system, including preparing and planning for responsible system decommissioning and equipment management. This will be increasingly important as solar power deployment accelerates to meet decarbonization goals. Decommissioning a PV system is essentially installation in reverse, and requires:

- Powering down the system
- Dismantling equipment including the solar array, PV modules, balance of system hardware (e.g., wiring, inverters, and the racking and mounting system), any ancillary equipment and other features (e.g., fencing, foundations, communication systems)
- Removing components and materials from the project site for reuse, recycling, and residuals disposal
- Restoring the land (including roadways) and/or infrastructure to its original condition or for new use.

Solar PV system decommissioning typically occurs at the end of a performance period as defined in a financial prospectus, power purchase agreement, land lease, or other system performance contract. The end of performance period for a PV system is often tied to the lifetime of the main component of a system – the solar PV module – but may be set for a longer or shorter period.

Solar PV modules typically have manufacturer warranties of 25–30 years. Consequently, utility-scale solar PV systems are designed with contracts and an expected period of performance of 20–30 years. However, many systems continue to operate past the design lifetime and remain economically productive for 30+ years, while others are retired early. In practice, there are several scenarios that may prompt decommissioning a PV system and/or a PV module equipment management decision independent of a PV system's expected period of performance. Examples include:

- Damage from natural disasters and extreme weather
- Federal, state, or local policy change (e.g., new interconnection or equipment standards result in the need to replace modules or inverters)
- Early equipment failure (e.g., PV module failure)
- Decreased performance and/or high operations and maintenance costs
- Failure to meet performance, financial, or insurance agreement terms.

These scenarios do not always trigger full system decommissioning. While not covered in this publication, alternatives to system decommissioning — such as extending the performance period, refurbishing, and repowering — are potential solutions to restore or enhance solar site energy production. These alternatives may also offer economic and environmental benefits compared to decommissioning.

## SYSTEM DECOMMISSIONING REQUIREMENTS

The asset owner may be required to comply with specific federal, state, or local government PV system decommissioning requirements. As of June 2023, the Bureau of Land Management (BLM) and 29 U.S. states have decommissioning policies that may apply to utility-scale PV systems.

The state policies include:

- **State-level** regulatory frameworks, in which state regulatory authorities oversee mandatory decommissioning requirements, are in place in 15 states (*Indiana, Louisiana, Maine, Minnesota, Montana, New Hampshire, New York, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, South Dakota, Vermont,* and *West Virginia*).
- **Hybrid state/local level** regulatory frameworks, in which state and/or local government regulatory authorities oversee mandatory decommissioning requirements, are in place in 13 states (*California, Hawaii, Illinois, Kentucky, Maryland, Michigan, Nebraska, New Jersey, Oklahoma, Tennessee, Texas, Virginia,* and *Wyoming*).
- **Optional state-level** decommissioning programs, which allow a solar developer to submit a decommissioning plan and proof of assurance to a state entity in lieu of obtaining local city and county government permits and approvals, exist in 1 state (*Washington*).

The remaining 21 states and the District of Columbia leave solar decommissioning to local governments. Of those 21 states, four (*Georgia, Iowa, Massachusetts, Wisconsin*) have model ordinances, templates, or other resources that asset owners and local governments may – but are not required to – use. Figure 2 shows U.S. states with solar decommissioning policies that may apply to utility-scale PV projects.

***Figure 1.*** *Plastic-wrapped pallets of PV modules awaiting transport to a reuse and recycling center during decommissioning of 187 $kW_{DC}$ rooftop PV system at EPRI's Palo Alto, California headquarters buildings, 2019*

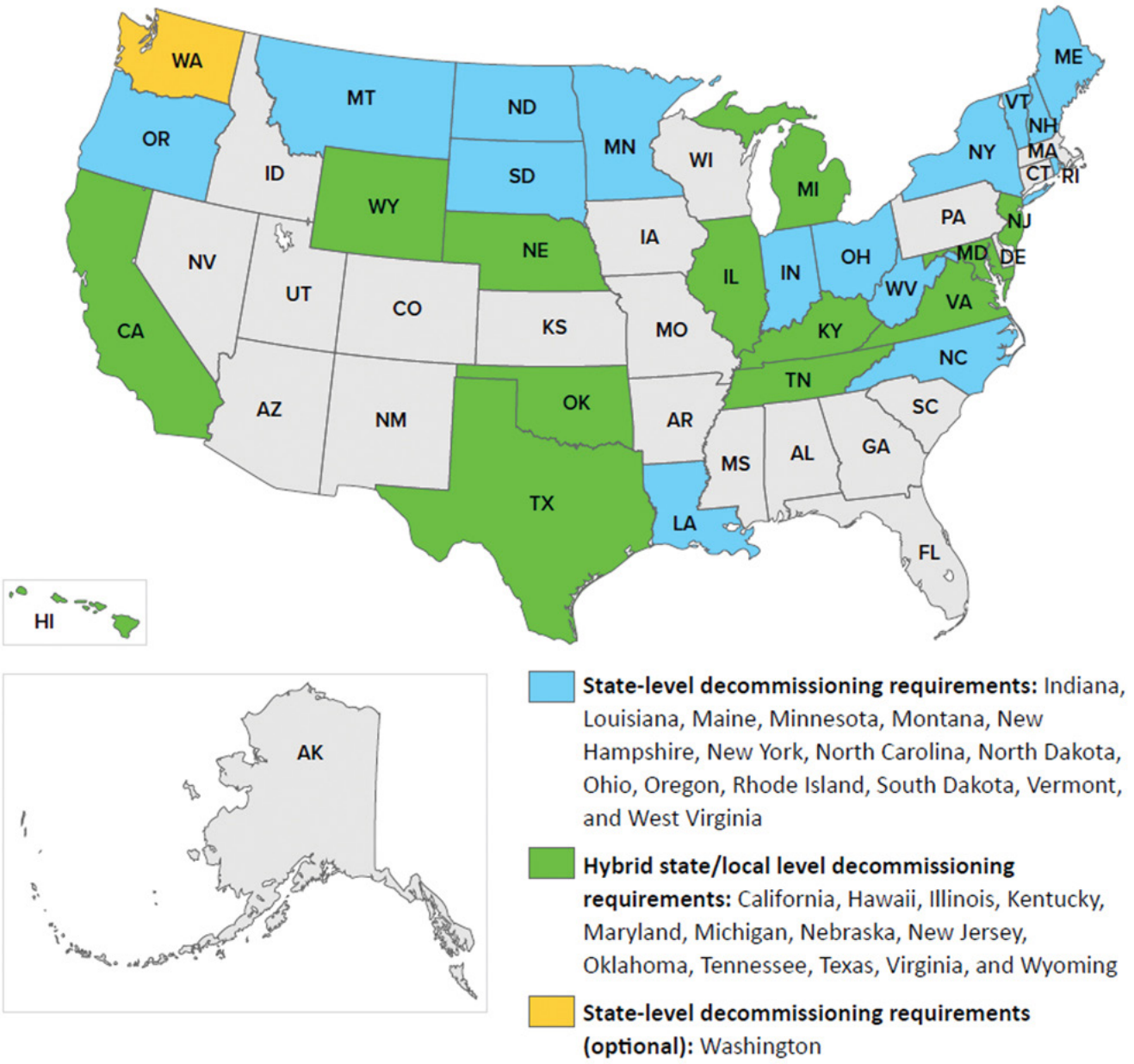



***Figure 2.*** *Summary of states with decommissioning policies applicable to utility-scale PV systems (as of June 2023)*

Solar decommissioning policies vary across U.S. jurisdictions and prescribe different requirements in each jurisdiction. Although no policy is the same, solar decommissioning policies often apply to utility-scale solar projects and are often tied to an approval required for initial project development, typically as a condition or term of approval (e.g., right-of-way, construction/operation permit). In addition to acknowledging responsibility for decommissioning, policies often require that the asset owner submit a decommissioning plan and/or provide financial assurance to the regulated entity with authority. Table 1 lists BLM and U.S. state decommissioning policies and associated requirements for a decommissioning plan or financial assurance.

***Table 1.*** *Summary of U.S. Federal and State Solar PV Decommissioning Policies (as of June 2023)*

| STATE | POLICY TYPES | REGULATORY THRESHOLD | KEY REGULATORY REQUIREMENT | CITATION |
|---|---|---|---|---|
| **BLM** | Federal | As a condition for approval for a solar right-of-way sites approval, the applicant | Must submit a decommissioning plan and provide financial assurance to BLM | 43 C.F.R. §2801.2 –2809.19 |
| **California** | Hybrid state/local | As a condition to the grant of a "solar use easement," an "owner of a solar use easement project" | Must submit a decommissioning plan, and financial assurance (resubmission required every 5 years) to the local city or county government with jurisdiction prior to construction[1] | Cal. Code Regs. tit. 14 §§ 3101, 3102, 3108, 3109, 3111.<br>Cal. Code Regs. tit. 5 § 51191.3. |
| | | As a term of an operating permit for "renewable energy generation facility sited on disturbed mined lands," the facility owner | Must submit a decommissioning plan and financial assurance to the agency with jurisdiction | Cal. Pub. Res. Code §2777.3 |
| **Hawaii** | Hybrid state/local | As a condition of a "special use permit, the owner of a solar energy facility located on agriculture lands with a soil productivity rating of B or C" | Must submit proof of financial assurance to the local county planning commission with jurisdiction. No decommissioning plan is required | Haw. Rev. Stat. §205-4.5(21); 205-6 |
| **Illinois** | Hybrid state/local | The owner of a "commercial renewable energy facility located on agricultural land owned by a third party" | Must submit a deconstruction plan (including system decommissioning) and financial assurance to the county with jurisdiction prior to project construction (resubmission of the deconstruction plan required every 10 years)[2] | Haw. Rev. Stat. §205-4.5(21); 205-6 |
| **Indiana** | State level | As a condition of a grant of a "commercial solar energy permit, the owner of a commercial solar energy facility" | Must submit a decommissioning plan, and a financial assurance to the permit authority with jurisdiction | Ind. Code § 8-1-42-18 |
| **Kentucky** | Hybrid state/local | As a condition for a "site compatibility certificate, the owner of a solar merchant electric generating facility occupying either 10 acres or more of space or 10MW or more in capacity" | Must submit a site assessment report that includes a decommissioning plan (resubmission required every 5) years, and proof of a financial assurance (must be updated every 5 years) to the Kentucky State Board on Electric Generation and Transmission Siting | K.R.S §§278.704;708 |
| **Louisiana** | State level | As a term of "an alternative energy source lease, the owner of an alternative energy source facility located on state land" | Must submit a decommissioning plan (resubmission required every 5 years) and financial assurance to the Louisiana Department of Natural Resources | La. Admin. Code tit. 43: V.921, 961, 967<br>La. Rev. Stat. § 30:1154 |

1 In addition, some California cities or counties may also require that the California Energy Commission approve the decommissioning plan as a condition to the grant of a conditional use permit.

2 In 2023, the Illinois General Assembly passed Public Act 102-1123, which mandates that the Illinois Department of Agriculture's standard agricultural impact mitigation agreement preempts any county laws that demand higher standards for decommissioning solar farms. This preempts counties from implementing more stringent standards then prescribed by the standard state agricultural impact mitigation agreement.

***Table 1 (continued).*** *Summary of U.S. Federal and State Solar PV Decommissioning Policies (as of June 2023)*

| STATE | POLICY TYPES | REGULATORY THRESHOLD | KEY REGULATORY REQUIREMENT | CITATION |
|---|---|---|---|---|
| **Maine** | State level | As a condition of "constructing or operating a solar energy development where any portion of the development located on land classified as farmland any time within 5 years preceding the start of construction of the development, the owner of ground-mounted solar panels occupying 3 or more acres" | Must submit a decommissioning plan and financial assurance (updated 15 years after approval of the plan and no less frequently than every 5 years thereafter) to the Maine Department of Environmental Protection or the Maine Land Use Planning Commission | Me. Rev. Stat. tit. 35-A §§ 3491-3496 |
| **Maryland** | Hybrid state/local | "Major (producing over 2 MW of electricity) and minor solar energy generating systems (producing less than 2 MW of electricity but not including a small residential accessory solar energy generating system) in an intensely developed area, a limited development area, and a resource conservation" | Must submit a decommissioning plan to the authority with jurisdiction. Financial assurance is not required | Md. Code Regs. 27.01.14.01, 27.01.14.04 |
| **Michigan** | Hybrid state/local | As a condition to the grant of a commercial solar agreement required for a solar farm located on Farmland Development Rights Program land, a solar farmer owner | Must submit financial assurance to the local jurisdiction. A decommissioning plan is not required | Mich. Dep't of Agric. and Rural Dev., *Policy for Allowing Commercial Panel Development on PA 116 Lands* |
| **Minnesota** | State level | As a condition of a site license, "the owner of a large electric power generating plant" | Must submit a decommissioning plan and financial assurance to the Minnesota Public Utilities Commission prior to issuance of the site license | Minn. Stat. §216E.01-02; Minn. R. 7854.0500. |
| **Montana** | State level | "Owner of a facility with a capacity of 2 MW or greater" | Must submit a decommissioning plan 12 months prior to operation of the facility and financial assurance any time prior to 15$^{th}$ year of the facilities operation (resubmit every 5 years) | Mont. Admin. R. 17.86.101, 102, 17.86.105 |
| **Nebraska** | Hybrid state/local | "Owner of a solar energy system who executes a solar agreement to secure a land right for a solar energy system" | Must include in the solar agreement a description of any decommissioning plans or financial assurance required by the local jurisdiction | Neb. Rev. Stat. § 66.911-01 |
| **New Hampshire** | State level | As a condition of approval for "a certificate of site and facility, the owner of an energy facility larger than 30 MW" | Must submit a decommissioning plan and financial assurance to the New Hampshire Site Evaluation Committee prior to construction of the facility | N.H. Rev. Stat. Ann. § 162-H:2(VII), (XII), 7 |

***Table 1 (continued).*** *Summary of U.S. Federal and State Solar PV Decommissioning Policies (as of June 2023)*

| STATE | POLICY TYPES | REGULATORY THRESHOLD | KEY REGULATORY REQUIREMENT | CITATION |
|---|---|---|---|---|
| **New Jersey** | Hybrid state/local | As a condition of approval for a site plan, an owner of a solar energy generation facility located on commercial farmland subject to the Right to Farm Act | Must submit a conservation plan (that addresses decommissioning) to the local soil conservation district with jurisdiction. Financial assurance is not required | N.J. Admin. Code § 2:76-2A.12 |
| | | An owner of a solar generation facility located in Pinelands Management Area | Must submit a landscaping plan (that addresses impacts of decommissioning) to the New Jersey Pinelands Commission. Financial assurance is not required | N.J.A.C. § 7:50-5.36 |
| **New York** | Hybrid state/local | As a condition of approval for "building permit, an owner of a major renewable energy facility" | Must submit a decommissioning plan and financial assurance to the local government entity with authority and the Office of Renewable Energy Siting (resubmission every 5 years) | NY. Comp. Codes. R. and Reg. tit. 19, § 900- 10.2; NY. Comp. Codes. R. and Reg. tit. 19, § 900-1.3; N.Y. Comp. Codes. R. and Reg. tit. 16 § 1001.29 |
| **North Carolina** | State level | An "owner of a utility-scale solar project (ground-mounted PV or concentrated solar power or PV 2 MW or more)" | Must submit a decommissioning plan and provide financial assurance to the North Carolina Department of Environmental Quality | N.C. Gen. Sta. §130A-309.240 |
| **North Dakota** | State level | As a condition of approval for a "certificate site and facility permit, the owner of a facility with a capacity of 500 kW or more" | Must submit a decommissioning plan and provide financial assurance to the North Dakota Public Service | |
| **Ohio** | State level | "As a condition of approval for a certificate of environmental compatibility and public need or a construction certificate issued by the Power Siting Board for a major utility facility (50 MW or more), an applicant" | Must submit a decommissioning plan and provide financial assurance to the Power Siting Board | Ohio Rev. Code §§ 4906.21 - 4906.222 |
| **Oklahoma** | Hybrid state/local | "A solar energy conversion system owner who executes a solar agreement to secure a land right for a solar energy conversion system" | Must include within the solar agreement any decommissioning plans or financial assurance required by the local jurisdiction where the energy facility is located. No state requirement to submit a decommissioning plan or financial assurance but to include in the solar agreement if required by the local government authority | Okla. Stat. tit. 60 § 820.1 |
| **Oregon** | State level | As a condition of approval for a site certification grant, an applicant | Must provide financial assurance to the Energy Facility Siting Council. A decommissioning plan is not required | OAR 345-022-000) |

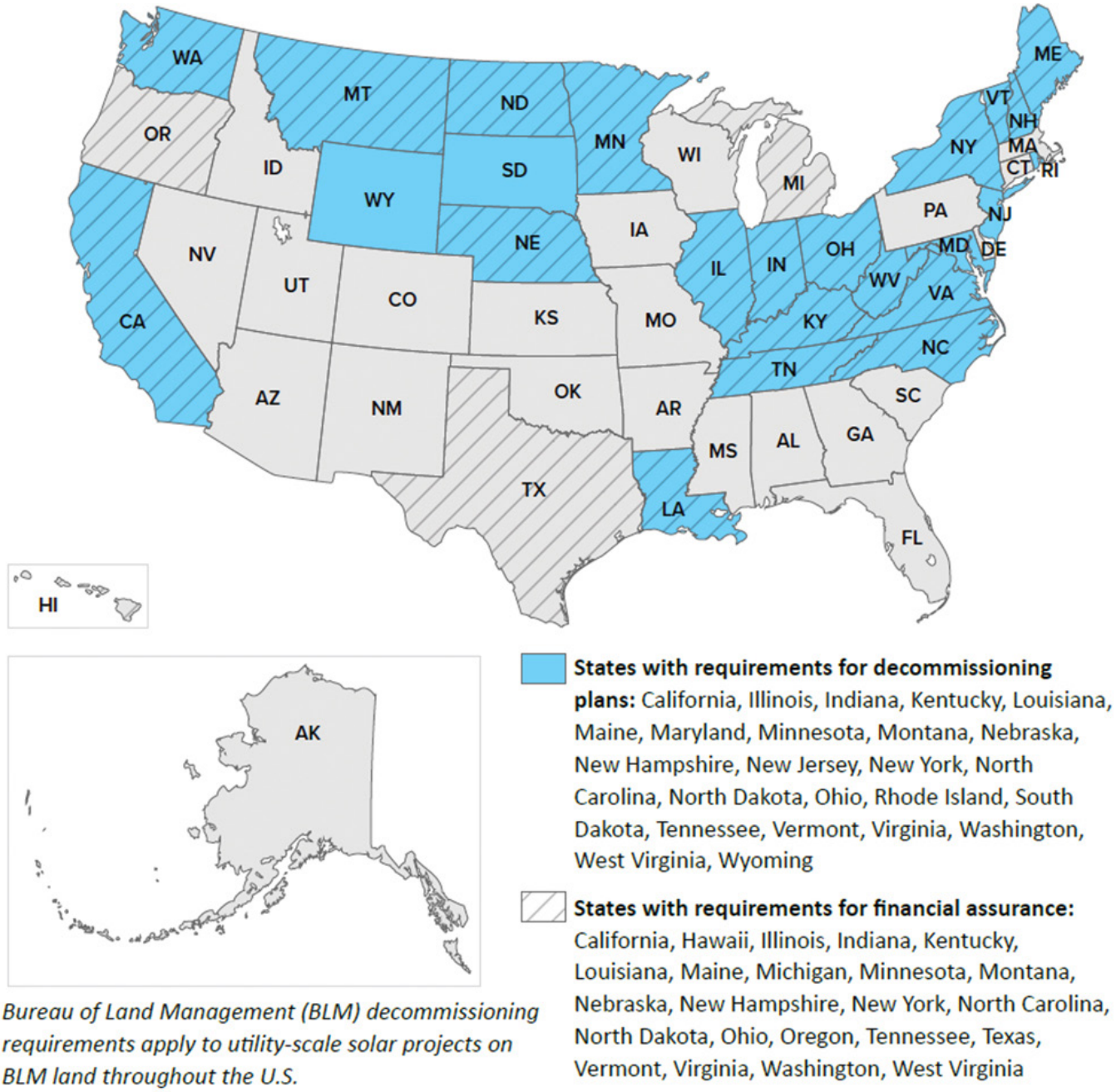
***Table 1 (continued).*** *Summary of U.S. Federal and State Solar PV Decommissioning Policies (as of June 2023)*

| STATE | POLICY TYPES | REGULATORY THRESHOLD | KEY REGULATORY REQUIREMENT | CITATION |
|---|---|---|---|---|
| **Rhode Island** | State level | As a condition for approval for "a major energy facility site license (operating capacity of 40 MW or more), the applicant" | Must provide a complement life cycle management plan (including plans for decommissioning) to the Rhode Island Energy Facility Siting Board. The Siting Board may require financial assurance | 42 R.I. Gen. Laws Ann. § 42-98-<br>42 R.I. Gen. Laws Ann. § 42-98-8 (a)(6)<br>880 R.I. Code R. §00-00-4.14(B) |
| **South Dakota** | State level | As a condition for approval of a "construction and operation permit, the owner of a solar energy facility (100 MW hundred MW or more)" | Must provide a decommissioning plan to the South Dakota Public Utilities Commission. The Commission may require financial assurance | S.D. Admin. R. 20:10:22:33.01<br>S.D. Code §49-41B-39 |
| **Tennessee** | Hybrid state/local | A solar power facility agreement between a landowner and a grantee | Must include a decommissioning plan and financial assurance in the facility agreement | Tenn. Code § 66-9-207 |
| **Texas** | Hybrid state/local | A solar power facility lease between a landowner and a grantee | Must include financial assurance. A decommissioning plan is not required. | Tex. Util. Code § 302.0004<br>Tex. Util. Code Tit. 6, Sec. A302.0001 |
| **Vermont** | State level | As a condition of approval for "a certificate of public good, the owner of a facility with a capacity of 500 KW or more" | Must submit a decommissioning plan and provide financial assurance (updated every 3 years) to the Vermont Public Utility Commission | 30 V.S.A §248<br>Vt PUC Rule 5.904 |
| **Virginia** | Hybrid state/local | Local governments must require owners of solar energy equipment, facilities, or devices or as a condition of approval of a site plan | Must submit a decommissioning plan and financial assurance to the local entity with jurisdiction | Va. Code Ann. § 15.2-2241.2<br>Va. Code Ann. § 67-103 |
| **Washington** | Voluntary | A developer of an alternative energy facility may choose to apply for a site certificate from the Washington State Energy Facility Site Evaluation Council (preempts local authorities). As a condition of approval for "a site certificate, an applicant" for an alternative energy facility | Must submit a site restoration plan which must include a decommissioning plan and financial assurance to Washington State Energy Facility Site Evaluation Council if the developer chooses to apply for a site certificate | Wash. Admin. Code 463-68-020<br>Wash. Admin. Code 46-72-040<br>Rev. Code Washington 80.50.110<br>Rev. Code Washington 80.50.120 |
| **West Virginia** | State level | An owner of solar generating facility with a nameplate capacity of 1 MW or more | Must submit a decommissioning plan and provide financial assurance to the West Virginia Department of Environmental Protection | W.V. Code Ann. §§22-32-3 – 8 |
| **Wyoming** | Hybrid state/local | As a condition of approval for an operating permit for a solar energy facility (more than 500 kW), the applicant | Must submit a decommissioning plan (resubmission every 5 years) to the county board of commissioners with jurisdiction. Financial assurance is not required | Wyo. Stat. Ann. §§18-5-501 – 502 |

## DECOMMISSIONING PLAN

BLM and 23[3] of the 29 U.S. states with solar decommissioning policies require a solar developer to submit a decommissioning plan to the federal, state, and/or local regulatory authority with jurisdiction. A developer in Washington State who *chooses* to obtain a Site License from the Washington State Energy Facility Site Evaluation Council instead of from a local government authority would also need to submit a decommissioning plan as condition of approval. A developer in Nebraska and Oklahoma may also be required to submit a decommissioning plan to the appropriate authorities if required by the local jurisdiction.

3 California, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Minnesota, Montana, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Rhode Island, South Dakota, Tennessee, Vermont, Virginia, West Virginia, Washington, and Wyoming




*Bureau of Land Management (BLM) decommissioning requirements apply to utility-scale solar projects on BLM land throughout the U.S.*

***Figure 3.*** *Summary of states with requirements for decommissioning plans or financial assurance for utility-scale PV systems (as of June 2023)*

The requirements for a decommissioning plan vary across jurisdictions but often require the following information:

- The lifespan of the solar system
- A site reclamation plan, a restoration plan, or both
- Plans for transportation, salvage, and disposal of solar system equipment and infrastructure (e.g., modules, inverters, supports, and cables)
- Cost estimates for solar system decommissioning (e.g., costs for removal of the solar system equipment and infrastructure, land restoration and reclamation, and insurance requirements)
- A description of any expected impacts on natural resources
- Estimated timelines for completion of decommissioning activities

***In addition to the typical information, California requires that decommissioning plans also include a soil management plan, site restoration plan, and description of regrading and removal of structures and equipment.***

## FINANCIAL ASSURANCE

BLM and 22[4] of the 29 U.S. states with solar decommissioning policies require a solar developer to provide proof of financial assurance to the federal, state, and/or local regulatory authority with jurisdiction. A developer in Washington State who *chooses* to obtain a site license from the Washington State Energy Facility Site Evaluation Council instead of from a local government authority would need to provide financial assurance as a condition of approval. Developers in Nebraska, Oklahoma, Rhode Island, and South Dakota may also need to provide financial assurance if required by the local government authority with jurisdiction.

***Indiana requires a project owner to post a bond or security equal to 25% of the total estimated decommissioning costs by the start of commercial operation, 50% by the 15th anniversary of the start date, and 100% by the 20th anniversary.***

## OTHER DECOMMISSIONING REQUIREMENTS

Decommissioning policies may also prescribe additional requirements, such as:

- Acknowledgement of decommissioning responsibilities of asset owner and what constitutes project abandonment
- Submission of notice and/or plan prior to decommissioning
- Submission of a decommissioning plan prior to construction or operation
- Specific details that must be included in a decommissioning plan
- Who must prepare the decommissioning plan
- A detailed decommissioning cost estimate, which may prescribe what is allowed to be included in the cost estimate, who must prepare the cost estimate, how the cost estimate must be calculated (e.g., salvage may not be included), and/or a requirement to recalculate the cost estimate (e.g., every 5 years)
- Proof of financial assurance, which may prescribe a specific type of financial assurance instrument (e.g., surety bond, trust, guarantee), when the financial assurance is required (prior to construction, during operation), the amount of financial assurance required, and/or how the cost estimate must be calculated
- Removal of system equipment
- Site restoration
- Post-decommissioning monitoring, reporting and closure requirements.

4 California, Hawaii, Illinois, Indiana, Kentucky, Louisiana, Maine, Michigan, Minnesota, Montana , New Hampshire, New York, North Carolina, North Dakota, Ohio, Oregon, Tennessee, Texas, Vermont, Virginia, Washington, and West Virginia

## PV MODULE MANAGEMENT

In accordance with the U.S. Environmental Protection Agency (EPA), PV modules taken out of service for end-of-life (EoL) management are categorized as general waste and are subject to a hazardous waste determination under the Resource Conservation and Recovery Act (RCRA). Other federal, state, or local policies may apply to the handling, transport, storage, treatment, recycling, and disposal of PV modules, including those regulated as hazardous waste. For example, U.S. Department of Transportation hazardous material regulations may apply to EoL PV modules being transported to a recycler or landfill.

In recent years, California and Hawaii adopted a policy that allows PV modules being recycled or landfilled to be managed as universal hazardous waste. Universal hazardous waste regulation in these states allows for less-stringent collection restrictions and requirements compared to fully regulated hazardous waste, but the requirements/restrictions that apply to asset owners, handlers, transporters, and recyclers of EoL PV modules vary by state. California imposes additional packaging requirements for transporting more than 200 pounds of PV modules and restricts storage up to 1 year while Hawaii does not. Washington State also recently passed a law to go into effect in 2025 that would require PV module manufacturers that sell into the state to take back EoL PV modules from customers at no charge and reuse or recycle 85% of modules collected. These various and recent policy adoptions have led the EPA, alongside several states (e.g., Illinois, Indiana, Minnesota, New Jersey, New York, and North Carolina), to study current regulatory/policy opportunities and challenges related to PV module circularity to inform future policy.

While the asset owner is responsible for removing PV modules at the time of system decommissioning, only one solar decommissioning policy analyzed (North Carolina) requires recycling or any other specific disposition other than removal from the project site. North Carolina's decommissioning policy requires that the asset "owner collect and ship for reuse or recycling all components, including the PV modules, practicably capable of being recycled."[5]

Depending on the age and condition of PV modules at the time of decommissioning, disposition options may include repair, reuse through donation or resale, long-term storage, recycling, or landfill disposal. Considerations that might influence PV module management decisions include:

- Time and labor to assess PV module condition and determine if repair and/or reuse is feasible
- Availability and price of recycling and refurbishment services
- Logistical feasibility of transporting PV modules across state lines, impacted by lack of uniform policy regarding PV modules
- Tax savings for donations
- Corporate sustainability goals.

This study included a review of 22 PV decommissioning plans across 13 states,[6] 9 of which have decommissioning policies. Only 6 of the 13 states require a decommissioning plan for large-scale solar projects. Some of the plans analyzed indicate intentions to recycle PV modules, while others intend to resell modules to recover cost. Most of the plans imply that modules that cannot be easily recycled or resold will be disposed of in another manner. Of the 22 decommissioning plans or statements surveyed, only 4 plans identified specific recyclers or cited a specific recycling plan, while 2 committed to a zero-landfill policy.

5 N.C. Gen. Stat. §130A-309.240(b)(2).

6 California, Connecticut, Florida, Maine, Maryland, Nevada, New York, North Carolina, Ohio, Oregon, Texas, Virginia, Wisconsin

## OUTLOOK

This study provides an update on large-scale solar PV project decommissioning at a time of rapid deployment. While there is limited experience decommissioning PV facilities, regulations are emerging, primarily at the state and local level. PV module management services are expanding in anticipation of growing material streams. Funding to develop a solar PV circular economy is creating a growing body of research on decommissioning and module management. Insights on decommissioning practices and policies can support PV asset owners, utilities, and their customers plan for EOL management of PV systems. This study identified several R&D needs, including:

- Evaluate expected vs. actual decommissioning costs to inform decommissioning plans.
- Develop standardized cost estimation tools for decommissioning and repowering.
- Identify best practices for decommissioning as the industry gains experience.
- Assess the value proposition for second-life opportunities, including donation and resale.
- Evaluate the feasibility of different lifetime extension options that could delay decommissioning.
- Conduct technoeconomic analyses for high-value recycling technologies customized for PV modules to estimate future module management costs.
- Explore ways to streamline PV module hazardous waste determination.

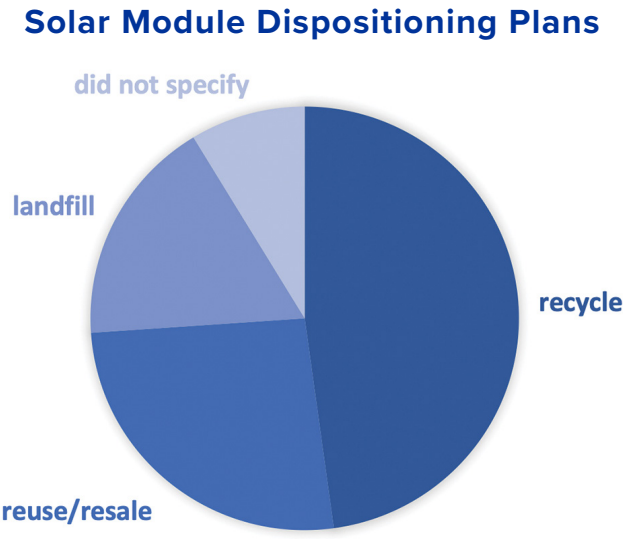



***Figure 4.*** *Insights on PV module dispositioning plans based on review of 22 decommissioning plans*

## DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

REFERENCE HEREIN TO ANY SPECIFIC COMMERCIAL PRODUCT, PROCESS, OR SERVICE BY ITS TRADE NAME, TRADEMARK, MANUFACTURER, OR OTHERWISE, DOES NOT NECESSARILY CONSTITUTE OR IMPLY ITS ENDORSEMENT, RECOMMENDATION, OR FAVORING BY EPRI.

**EPRI PREPARED THIS REPORT.**

This work was also authored in part by Taylor Curtis from the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC for the U.S. Department of Energy (DOE), Erica Howard from Battelle Memorial Institute, and Cara Libby, Gabrielle Siegfried, and Terry Jennings from EPRI. This material is based upon work supported by the National Science Foundation under Grant No. 49100423C0005.

## About EPRI

Founded in 1972, EPRI is the world's preeminent independent, nonprofit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

**EPRI CONTACT**

**CARA LIBBY**, *Principal Technical Leader*
*Environmental Aspects of Solar, P252*
650.776.6009, clibby@epri.com

**For more information, contact:**

**EPRI Customer Assistance Center**
800.313.3774 • askepri@epri.com

**3002028347** **February 2024**

**EPRI**
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 650.855.2121 • www.epri.com

© 2024 Electric Power Research Institute (EPRI), Inc. All rights reserved. Electric Power Research Institute, EPRI, and TOGETHER…SHAPING THE FUTURE OF ENERGY are registered marks of the Electric Power Research Institute, Inc. in the U.S. and worldwide.