

SOLAR PHOTOVOLTAIC DEVELOPMENT OF AGRICULTURAL LAND:

Observations, Analysis, and Research on Change in Use

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Table of Contents

- Executive Summary..... 3**
- Introduction: Change in Use Decisions on Rural North Carolina Lands..... 6**
- 1. Powering and Feeding North Carolina: A Sketch of North Carolina’s Agricultural Output and Projections of Electricity Need..... 9**
 - 1.1 North Carolina’s Lands in Farming..... 9
 - 1.2 North Carolina’s Electricity Needs and Renewable Energy Development Policy..... 12
- 2. Local Decisions in Solar Development on Agricultural Land..... 16**
 - 2.1 The Landowner’s Decision: Evaluating Alternatives..... 17
 - 2.1.1 Income Stream from the Solar Lease..... 19
 - 2.1.2 Solar Lease as Term-Limited Use..... 20
 - 2.1.3 Retained Wealth: Valuation of the Parcel Hosting Solar PV..... 22
 - 2.1.4 Impact on Farm Tenant/Lessee and Local Farm Economy..... 24
 - 2.1.5 Considering Dual Use: Agrivoltaics..... 26
 - 2.2 Addressing Concerns About Agricultural Impact in Permitting Decisions..... 30
 - 2.2.1 The Solar PV Permitting Process: Special Use Permits, Ordinance Changes, and Public Input..... 31
 - 2.2.2 Addressing Local Concern, Part I: Research on the Impact of Solar PV Development on Land Otherwise Available for Agricultural Production..... 34
 - 2.2.3 Addressing Local Concern, Part II: Available Research on the Impact of Solar PV Development on Surrounding Property Values..... 43
- 3. Solar Development Impacts on Farmland and Farmland Restoration..... 45**
 - 3.1 Impact on Soil Health..... 46
 - 3.1.1 Construction Grading and Compaction..... 46
 - 3.1.2 Changes in Soil Composition During Lease Term..... 48
 - 3.1.3 Erosion and Vegetation Management..... 50
 - 3.1.4 Soil Contamination Concerns: Material Leaching and Concepts of Toxicity..... 54
 - 3.2 Decommissioning Solar PV Facilities..... 60
- Conclusion..... 67**

Executive Summary

Rural areas in the United States are changing as more farmland is used for utility-scale solar photovoltaic (PV) projects. This white paper examines the economic, policy, environmental, and land-use issues that come with solar PV development on agricultural and farmland. It focuses on landowner decision-making, local permitting, impacts on farm productivity, and long-term care of the land.

Agriculture is a major part of many state economies, with millions of acres in use and billions of dollars in yearly sales. At the same time, electricity demand is rising because of population growth, more industry, electrification, and new technologies like artificial intelligence and large data centers. These trends are putting more pressure on rural landowners and local governments to find ways to balance farming with solar PV development.

Agricultural Land Use and Solar Development

Agricultural land is often a good fit for solar PV facilities because it is usually flat, already cleared, drains well, and is close to power lines. For these reasons, many regions prefer to use farmland for solar projects. Landowners can earn extra income by leasing their land for

solar, which can provide steady and reliable financial returns over a long period.

Additionally, utilizing agricultural land for solar development can affect several variables:

- Relationships between farm tenants and landowners, as well as the local farming economy
- The amount of land available for future farmers or for expanding existing farms
- How much the land is worth and the wealth that landowners keep
- Agricultural productivity post-solar lease

Solar PV projects usually last for a set number of years, usually under a 25-year lease, so the land can often be returned to agriculture once the solar equipment is removed. In many cases, this means the change in land use is temporary, not permanent.

Electricity Demand and Policy Factors

Many states expect electricity demand to grow a lot in the coming decades, driven by economic growth, more electric vehicles, and increased use of technology. Policies that require more renewable energy and programs that

plan for future energy needs have helped speed up solar PV development.

Large solar farms now provide more of the electricity used in different regions and cover hundreds of thousands of acres of farmland across the country. Each megawatt of solar power usually needs five to seven acres, showing how much land is involved in these projects.

The cost to build solar projects has dropped from over \$5 per watt in 2009 to about \$1 per watt recently. This big price drop has made solar projects more economical and led to more being built.

North Carolina as a Case Study

North Carolina is a representative example of how major agricultural states are navigating the intersection of farmland preservation and solar energy deployment. As one of the leading states in utility-scale solar capacity, the state has experienced growth in solar installations on agricultural land over the past decade.

Local governments in North Carolina play a fundamental role in siting and permitting solar facilities through zoning ordinances and special use permits, having to balance sometimes competing priorities such as economic development, land conservation, and community impacts. Public review processes frequently address concerns

related to farmland preservation, property value and visual impacts, environmental effects, and soil health.

Studies in North Carolina indicate that solar PV development does not consistently result in significant negative impacts on surrounding property values, though outcomes may vary by site and project size.

Additionally, vegetation management beneath solar arrays may support erosion control and improve certain soil characteristics relative to intensive crop production.

Soil Health and Environmental Impacts

Building solar facilities can disturb soil in the short term due to grading, compaction, and removing plants. Over time, though, managing vegetation under the panels can reduce erosion and improve some soil qualities compared to intensive farming.

This paper addresses concerns related to:

- Soil compaction and grading
- Changes in soil health during facility operation
- Erosion control and vegetative management
- Potential material leaching and toxicity risks

Research shows that best management practices and proper decommissioning can help reduce environmental risks.

Decommissioning and Land Restoration

A critical factor in solar land-use decisions is the ability to restore agricultural functionality following a facility's decommissioning.

Decommissioning plans typically require removal of panels, racking systems, and ancillary equipment, as well as remediation of soil conditions to what they were before facility construction began.

Good restoration methods include loosening compacted soil, planting native or farm crops again, and removing hard surfaces and foundations. If done well, these steps can make the land suitable for farming again, showing that solar PV projects can be a temporary use of farmland.

Development Implications

Solar PV deployment on agricultural land represents both an economic opportunity for rural landowners and a planning and siting challenge for local governments that want to preserve long-term agricultural viability.

Policymakers and stakeholders must weigh short-term financial gains and energy-related benefits against potential impacts on local farm economies and land availability.

Further research is needed to evaluate aggregate economic effects, long-term soil outcomes, and best practices for integrating dual-use such as agrivoltaics that allow simultaneous agricultural production and solar energy generation.

Conclusion

As North Carolina and other states add more solar energy generation, farmland will continue to be important for placing solar projects. Moving forward, cognizant planning, transparent permitting processes, and informed land stewardship practices are essential to ensuring that solar PV development complements, rather than compromises or deters, agricultural productivity and rural community resilience.

Introduction: Change in Use Decisions on Rural North Carolina Lands

North Carolina hosts one of the most diverse agricultural production economies in the United States, with several number one national production rankings for various crops. The food, fiber and forestry industry - collectively agribusiness - value to North Carolina's economy is estimated at \$102 billion.⁴ Of that figure, \$18.5 billion is from agricultural (non-timber) products sold including the green industry, produced from an estimated **8.1 million acres** of farmland.⁵ Together, the agribusiness sector is North Carolina's third-largest industry, behind manufacturing and real estate.⁶ In the Carolinas and the U.S. the spheres of "change in use" are extending further from suburban into rural areas, attracted by a number of

factors including transportation infrastructure, low population density, and access to the power grid. This last factor - along with public policy incentives in favor of diversifying electricity sources - has led to a significant increase in renewable electricity generation as one of several changes in use for non-farm development of rural land. Since 2007, North Carolina has ranked in the top-five states for solar photovoltaic (PV) development and production. The concern that any non-farm development of land is a threat to domestic agricultural production is well documented.⁷

Siting and construction experience in North Carolina has shown that agricultural lands - cleared, often flat, and reasonably drained - are well-suited to development for renewable generation facilities when such lands co-locate with suitable transmission lines. Like any non-farm development such as residential and commercial, such facilities present a change in use

⁴ Dorfman, J. (2025). *N.C. Agriculture's Economic Impact*. N.C. State University College of Agriculture & Life Sciences. <https://www.ces.ncsu.edu/wp-content/uploads/2025/11/2025-N.C.-Agriculture-Impact-Report-1-Pager.pdf?fw=no>

⁵ U.S. Department of Agriculture, National Agriculture Statistics Service (2024). *2022 Census of Agriculture: Volume 1, Chapter 1, State Level: North Carolina, Table 1*. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/North_Carolina/st37_1_001_001.pdf.

⁶ North Carolina Department of Commerce. (2025). *The industries driving North Carolina's economy: A GDP-based analysis*. Retrieved November 10, 2025 from <https://www.commerce.nc.gov/news/the-lead-fee-d/industries-driving-north-carolinas-economy>

⁷ Hunter, M., A. Sorensen, T. Nogeire-McRae, S. Beck, S. Shutts, R. Murphy. (2022). *Farms Under Threat 2040: Choosing an Abundant Future*. American Farmland Trust. https://farmlandinfo.org/wp-content/uploads/sites/12/2022/08/AFT_FUT_Abundant-Future-7_29_22-WEB.pdf

option for owners of land in farm use. As the American economy increasingly diversified in the later 20th century with evolving agricultural production technology and market structure, farm enterprises generally are fewer in number and larger in size, with an ever-increasing average age of the principal farm operator.⁸ The corresponding result has been a steady decline in the number of rural residents who manage their land for farm production as a primary source of income. Many farmers “who were the last generation to farm” land acquired by immediate or distant ancestors, have or will distribute their land wealth to non-farming heirs who continue to hold it or have sold it. Now, relatively few rural landowners manage the agricultural production on land they own, but receive payment from others for its use, principally farm rent and conservation payments. In other words, the “landowner’s decision” is less a matter of holding and managing land for its farm production value to make a living, but rather what use - agricultural and timber or otherwise - will bring the highest return from someone else’s use of the land.

⁸ U.S. Department of Agriculture, National Agricultural Statistics Service. (2024). *2022 Census of Agriculture: State and County Data, North Carolina (Vol. 1, Chapter 2)*. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1_Chapter_2_County_Level/North_Carolina/

The relatively new use of solar PV development represents a visible change to the landscape. Much has been written about the loss of farmland to residential development. The principal voice in this arena - American Farmland Trust (AFT) - has made various predictions on loss of farmland over the coming decades, absent the intervention of steady land use planning and incentives for relinquishing non-farm development opportunity on participating parcels of farmland.⁹ AFT and researchers at the University of Madison-Wisconsin examined national patterns of farmland conversion to urban and highly developed land uses and low-density residential areas. They predicted that under what they call “a business-as-usual” scenario, 18.4 million acres of farmland will be converted by 2040, with most (12.2 million acres) converting to residential.^{10,11} In North Carolina and South Carolina, those researchers predicted a conversion of 1,197,300

⁹ Ibid.

¹⁰ Hunter, M., A. Sorensen, T. Nogeire-McRae, S. Beck, S. Shutts, R. Murphy. (2022). *Farms Under Threat 2040: Choosing an Abundant Future*. American Farmland Trust. https://farmlandinfo.org/wp-content/uploads/sites/2/2022/08/AFT_FUT_Abundant-Future-7_29_22-WEB.pdf

¹¹ Xie, Y. and Lark, T. (2022). *Description of the approach, data and analytical methods used for the Farms Under Threat 2040 projections of future agricultural land conversion. Technical Report*. Center for Sustainability and the Global Environment, University of Wisconsin-Madison. https://www.farmlandinfo.org/wp-content/uploads/sites/2/2022/06/FUT2040-Development-Modeling-Technical-Report_05312022.pdf

acres and 436,682 acres, respectively.¹² Though other uses – such as residential and industrial – are no less noticeable, solar PV use often differs in scale of acreage used, is a relatively new use, and has reached “further” into traditionally rural areas at a relatively faster pace - in just two decades - than the residential development competing for land in areas closer to urban centers.

This white paper explores the nature of the change in use between agriculture and renewable energy land use, and addresses popular understanding of the impacts of such change. Particular attention is devoted to the available research on a variety of issues and real challenges. Topics addressed result from the authors’ experiences in working with local stakeholders and county governments as part of the **Carolinas Development Assistance and Siting Hub (Carolinas DASH)**, funded by the U.S. Department of Energy (DOE) as part of the **Reliable Energy Siting through Technical Engagement and Planning** (R-STEP) program.

Though covering policy and various particulars in both North and South Carolina, there is more emphasis on the

former given the authors’ knowledge and experiences in North Carolina, specifically relating to its farming economy, electricity need projections and procurement regime, and zoning law. Much of the underlying framework may be informative across applications in different states, and much of the review of the literature and processes pertaining to agrivoltaics, agricultural land use, property values, soil health, toxicity, material leaching, water quality, and decommissioning is broadly applicable.

Most premises presented in this white paper are supported by citation, and there may not always be a counterpoint similarly supported; the authors recognize there is much research to explore on the issues highlighted in this paper. To that end, the authors invite and welcome scrutiny and feedback on the assertions, observations and suggestions of research methods for addressing the issues raised.

More in-depth treatment of adjacent topics (e.g. solar PV recycling, health and safety, decommissioning, etc.) may be found on the **Carolinas DASH** online technical assistance hub:

carolinas-dash.org.

¹² Hunter, M., A. Sorensen, T. Nogeire-McRae, S. Beck, S. Shutts, R. Murphy. (2022). *Farms Under Threat 2040: Choosing an Abundant Future*. American Farmland Trust. https://farmlandinfo.org/wp-content/uploads/sites/12/2022/08/AFT_FUT_Abundant-Future-7_29_22-WEB.pdf

1. Powering and Feeding North Carolina: A Sketch of North Carolina's Agricultural Output and Projections of Electricity Need

As this white paper explores the change in use between agricultural production lands and solar PV development, it is important to highlight the economic importance and public need and reliance on both. The discussion below places in context the extent of production on lands that have been found suitable - perhaps prioritized - during the past two decades of solar PV use development across North Carolina, with an overview of the energy needs driving these changes in land use.

1.1 North Carolina's Lands in Farming

As noted above, North Carolina's farm production exceeds \$18 billion in annual sales, placing North Carolina at number eight in the United States.¹³ This production is supplied by 42,500 farms on 8.1 million acres of land - identified

¹³ U.S. Department of Agriculture, National Agricultural Statistics Service (2024). *2022 Census of Agriculture: Farm Economics Highlights*. https://www.nass.usda.gov/Publications/Highlights/2024/Census22_HL_FarmEconomics_FINAL.pdf.

as "land in farms" - according to the United States Department of Agriculture's (USDA) 2022 Census of Agriculture, a survey performed on five-year cycles by the USDA's National Agricultural Statistics Service (NASS).¹⁴ While North Carolina farm sizes vary widely in revenue and acreage, the larger farm firms (classified as sales above \$100,000/year) produce on 5.3 million acres of the total "land in farms."¹⁵ A categorical subset of this total, land defined as "harvested cropland," is 4.3 million acres, or 53% of total reported "land in farms." The census reports that the amount of total land devoted to farming of all types has declined by 400,000 acres since 2014.¹⁶ A subset of lands in agricultural use are categorized as prime soils - officially termed **prime farmland** by the USDA under the Farmland Protection Policy Act (FPPA) -

¹⁴ U.S. Department of Agriculture, National Agricultural Statistics Service (2024). *2022 Census of Agriculture: State and County Data, North Carolina Volume 1, Chapter 2*. <https://www.ncagr.gov/divisions/agricultural-statistics>

Note: The five-year census is managed in cooperation with each state's department of agriculture (e.g. in North Carolina, the NC Department of Agriculture and Consumer Services' Agricultural Statistics Division).

¹⁵ U.S. Department of Agriculture, National Agricultural Statistics Service (2025). *2024 North Carolina Agricultural Statistics 2-3*. https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/Annual_Statistical_Bulletin/AgStat/NCHighlights.pdf

¹⁶ U.S. Department of Agriculture, National Agricultural Statistics Service (2025). *2024 North Carolina Agricultural Statistics 2-3*. https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/Annual_Statistical_Bulletin/AgStat/NCHighlights.pdf

referring to land that possesses the “best combination of physical and chemical characteristics” for producing food, feed, forage, fiber, and oilseed crops.¹⁷ These characteristics include **soil quantity and quality** (deep soil typically >40 inches to bedrock with high permeability to allow water and air movement), **pH balance** (acidity or alkalinity (pH) is within an acceptable range [4.5 to 8.4] in the root zone), **low erodibility** (low susceptibility to erosion by water or wind, where the soil surface is generally level or gently sloping [typically <6% slope], and access to water and not typically prone to flooding).¹⁸ Prime soils are identified by the USDA’s Natural Resource Conservation Service (NRCS) using the Gridded Soil Survey Geographic Database (gSSURGO)¹⁹ and the National Resources Inventory (NRI).²⁰ Though NRCS does not publicize total acreage figures of prime soils for North and

South Carolina, such analysis can be made with these tools on a county by county basis. In Piedmont regions, prime soils generally consider slope and erodibility; in the coastal plain, the principal factor is drainage.

North Carolina consistently ranks as one of the most diverse agricultural production states (usually behind California and Florida).²¹ The state is the top national producer of sweet potatoes, tobacco, and the combined total of poultry and egg sales; number two in turkeys and trout; and number three in hogs (behind Iowa and Minnesota),²² peanuts and cucumbers.²³

¹⁷ 7 U.S.C. § 4201(c)(1) (2018).

Note: The FPPA, enacted in 1981, guides federal policy by establishing a requirement for federal agencies to minimize the unnecessary and irreversible conversion of farmland to non-agricultural uses; it is not a regulation concerning private land use.

¹⁸ 7 C.F.R. § 657.5(a) (2025).

¹⁹ U.S. Department of Agriculture (2023). *Gridded National Soil Survey Geographic Database (gNATSGO) | Natural Resources Conservation Service. Natural Resources Conservation Service.* <https://www.nrcs.usda.gov/resources/data-and-reports/gridded-national-soil-survey-geographic-database-gnatsgo>

²⁰ U.S. Department of Agriculture. (2023b). *National Resources Inventory (NRI)*. Natural Resources Conservation Service. <https://www.nrcs.usda.gov/nri>

²¹ U.S. Department of Agriculture, National Agricultural Statistics Service (2024). *2022 Census of Agriculture: U.S. Summary and State Data Volume 1, Chapter 1.* https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1_Chapter_1_State_Level/North_Carolina/

²² U.S. Department of Agriculture, National Agricultural Statistics Service (2024). *Hogs and Pigs Annual Summary 10* https://www.nass.usda.gov/Publications/Todays_Reports/reports/hgpg0425.pdf

²³ U.S. Department of Agriculture, National Agricultural Statistics Service (2025). *2024 North Carolina Agricultural Statistics 2–3.* https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/Annual_Statistical_Bulletin/AgStat/NCHighlights.pdf

Breaking down “harvested cropland” acres by commodity, North Carolina’s farmland production according to NASS (as of 2022) is summarized as follows:

Commodity	Land Use Metric	Acres (Harvested/Planted)	Percent of Total Land in Farms
Soybeans	Harvested	1,600,000	20%
Corn (for Grain)	Harvested	810,000	10%
Hay (All)	Harvested	588,000	7%
Wheat (Winter)	Harvested	330,000	4%
Peanuts	Harvested	129,000	1.7%
Tobacco	Planted	114,000	1.4%
Sweet Potatoes	Harvested	86,500	1%

Regarding land devoted to grazing, according to the NASS data, the amount of North Carolina farmland classified as “pastureland” is 845,947 acres. This acreage is defined by NASS as open land for grazing livestock, which includes cattle, sheep, and other grazing animals. Given that the cattle and calves inventory in the state is substantial (over 700,000 head), those producers who raise these animals are the primary users of this pastureland. For context, this 845,947 acres figure represents about 10.4% of the total 8.1 million acres of agricultural land in North Carolina.

Setting aside any developer preference between row crop and pasture acreage, the key question appears to be: “What will be the impact to both individual livelihoods and the local and state farm and rural economies as continued procurement of electricity from large-acreage solar generating facilities continues?” The impact to the individual farm producer or firm may be easier to calculate on known variables of that operation, and the conversion cost of a farm parcel or field can be measured by its historical basis of productivity – much of it documented in Farm Service Agency reports.

Also, available land (to buy or rent) is often the lifeblood of farm succession - the gradual transfer of a farm operation to the next generation - whereby an operation often must expand enough to support multiple farmers participating in that operation. The aggregate impact to local and state farm economies presents a larger question requiring further study.

1.2 North Carolina's Electricity Needs and Renewable Energy Development Policy

The North Carolina Utilities Commission (NCUC) in consultation with Duke Energy Carolinas and Duke Energy Progress (North Carolina's principal utilities, collectively "Duke Energy") is required by statute to continually make projections on electricity needs for the coming decades.²⁴ Duke Energy is a regulated utility under Chapter 62 of the North Carolina General Statutes serving approximately 3.6 million of the state's retail electricity customers,²⁵ and is required under NCUC regulation to make 15-year projections on future

²⁴ N.C. Gen. Stat. § 62-110.1(c).

²⁵ Duke Energy. (2025). *Duke Energy proposes new investments in North Carolina to boost reliability and support economic growth across the state*. Duke Energy | News Center. <https://news.duke-energy.com/releases/duke-energy-proposes-new-investments-in-north-carolina-to-boost-reliability-and-support-economic-growth-across-the-state>

electricity needs, filed biennially with the North Carolina Utilities Commission.²⁶ This mandate requires a plan for meeting such projections in compliance with Least-Cost Integrated Resource Planning protocols, which seek to reduce consumer electricity prices to the extent practicable in the effort to meet projected electricity needs. The details of Duke Energy's most recent (October 2025) filing, explored below, serve as a call to meet a growth projection of 35,000 gigawatt-hours (GWh) through 2040, roughly eight times the growth experienced over the last 15 years.²⁷

For reference, North Carolina's 2024 "net summer peak" (considered the highest use period) of electricity service capacity is 36,337 MW (megawatts; or 36.337 GW (gigawatts)).²⁸ Regarding the current mix of energy sources, an estimated 85% of North Carolina's electricity is generated from combustion of coal and natural gas, and fission from uranium, all of which are extracted outside of North Carolina. Of these, natural gas accounts for 41%

²⁶ 4 N.C.A.C. 11 R8-60.

²⁷ Application of Duke Energy Carolinas, LLC & Duke Energy Progress, LLC for Approval of the 2025 Carolinas Resource Plan, N.C. Utils. Comm'n Docket No. E-2, Sub 1289 & E-7, Sub 1461, (filed Oct. 1, 2025).

²⁸ U.S. Energy Information Administration. (November 10, 2025). *North Carolina Electricity Profile 2024*. www.eia.gov. Retrieved November 10, 2025 from <https://www.eia.gov/electricity/state/northcarolina/>

of electricity generation, with North Carolina's three nuclear facilities together generating 33%. Though producing more than half of North Carolina's electricity prior to 2012, coal now contributes 11%. The remaining 15% of electricity demand is supplied by energy sources considered renewable which are solar, wind and hydro (the gravity flow of surface water), with 10% of that coming from solar.²⁹ The technologically advanced heirs of industrial-age electricity generation - steam turbines powered by coal combustion - have themselves advanced toward obsolescence and are being converted to gas or retired. Since 2012, 31 coal-fired combustion facilities with roughly 4,000 MW annually of generating capacity have been retired,³⁰ ³¹ with some currently being replaced by natural gas units and the advancing technology of battery storage.³²

²⁹ U.S. Energy Information Administration. (November 10, 2025). *North Carolina State Profile and Energy Estimates: Profile Analysis*. www.eia.gov. Retrieved November 10, 2025 from

<https://www.eia.gov/state/analysis.php?sid=NC>

³⁰ U.S. Energy Information Administration. (November 10, 2025). *North Carolina State Profile and Energy Estimates: Profile Analysis*. www.eia.gov. Retrieved November 10, 2025 from

<https://www.eia.gov/state/analysis.php?sid=NC>

³¹ Boraks, D. (2024). *Duke to Retire Coal-Fired Plant in Gaston County and Replace It with Battery Storage*. WFAE.

<https://www.wfae.org/energy-environment/2024-11-21/duke-to-retire-coal-fired-plant-in-gaston-county-and-replace-it-with-battery-storage>

³² Brown, A. (2025, August 11). States scramble to complete renewable energy projects before tax credits expire • NC Newline. NC Newline. <https://ncnewline.com/2025/08/11/states-scram>

Duke Energy has projected in their 2024 Consolidated Carbon Plan & Integrated Resource Plan (CPIRP) future power needs and the mix of sources to meet these needs.³³ Partially in response to the rapid advent of hyperscale data center facilities to process the public's increasing reliance on artificial intelligence (AI), along with North Carolina's growing population and commercial sectors in general, Duke Energy revised its projected energy mix by filing a new CPIRP in October 2025.

[ble-to-complete-renewable-energy-projects-before-tax-credits-expire/](#); Solar Energy Industry Association. (2024, September 8). *Solar Market Insight Report Q3 2025*. SEIA. <https://seia.org/research-resources/us-solar-market-insight/>

³³ In re: *Biennial Consolidated Carbon Plan & Integrated Resource Plans of Duke Energy Carolinas, LLC, & Duke Energy Progress, LLC*, Docket No. E-100 Sub 190 (N.C. Utils. Comm'n Nov. 1, 2024).

These revised figures - subject to further revision following public hearings and finalization by the end of 2026³⁴ - call for the following energy build-out:³⁵

Energy Source	Proposed Buildout or Action (Through 2034)
Natural Gas	Maintained five combined-cycle (CC) units for baseload, and added two new combustion turbines (CT) (totaling seven CTs) for peak demand.
Battery Storage	Expanded significantly to target 5,600 MW, an increase of 2,900 MW over the previous plan.
Solar PV	Targeted 4,000 MW (through competitive bidding) by 2034.
Nuclear	Expanded evaluation to include Large Light-Water Reactor (LLWR) technology alongside Small Modular Reactors (SMRs), targeting potential service by 2037 at sites like Belews Creek, North Carolina.
Coal	Targeted potential two- to four-year extensions for coal units with dual-fuel capability (e.g., Belews Creek, Cliffside, Marshall).
Wind	Omitted from the plan through 2040.

³⁴ Duke Energy. (2025b). *News Releases*. Duke Energy | News Center. <https://news.duke-energy.com/releases/duke-energy-files-2025-carolinas-resource-plan-continues-modernizing-energy-infrastructure-to-support-future-growth>

³⁵ *2025 Carolinas Resource Plan*, Docket No. E-100 Sub 207 (N.C. Utils. Comm'n Oct. 1, 2025).

Regarding the current capacity of solar generation, as of November 2025 there were 766 utility-scale solar facilities generating electricity in North Carolina, with 6,802 MW of capacity operating at a 20% capacity factor.³⁶ Eight solar facilities were completed in 2024.³⁷ The North Carolina Sustainable Energy Association (NCSEA), a research and advocacy group, estimates these facilities occupy approximately 40,200 acres of land, with approximately 34,000 of those acres considered agricultural land.³⁸ For reference, 1 MW of solar capacity occupies between 5 and 7 acres of land.³⁹ This solar capacity has been built out since 2007 in an era of renewable energy procurement mandates, coupled with facility investor incentives, including an 80% personal property tax abatement on facility components,⁴⁰ and state and federal investment tax credits. Such

³⁶ U.S. Energy Information Administration. (2026). *North Carolina State Profile and Energy Estimates*. [www.eia.gov](https://www.eia.gov/state/seds/data.php?infile=/state/seds/sep_fuel/html/fuel_cf.html&sid=N).
https://www.eia.gov/state/seds/data.php?infile=/state/seds/sep_fuel/html/fuel_cf.html&sid=N

³⁷ Thomas, M. (2025). *Cleanview*. Cleanview.co.

<https://cleanview.co/solar-farms/north-carolina>
³⁸ Carey, J., & Pate, D. (2025). *North Carolina Solar Land Use and Agriculture Study – 2025 Update* [Review of *North Carolina Solar Land Use and Agriculture Study – 2025 Update*]. North Carolina Sustainable Energy Association. Retrieved November 9, 2025, from
https://www.energync.org/wp-content/uploads/2025/11/2025_Solar_Ag_NCSEA_REV.pdf

³⁹ SolarLandLease. (2017, December 30). *How Much Land Does a Solar Farm Need?* SolarLandLease.
<https://www.solarlandlease.com/how-much-land-does-a-solar-farm-need>

⁴⁰ N.C. Gen. Stat. § 105-275(45) (2025).

mandates and incentives are a continuing result of North Carolina's policy response to federal energy diversification and domestication policy dating back to the 1970s.⁴¹

As with any emerging technology, a decline in solar facility component manufacturing costs, and an increase in panel and transmission performance and efficiency, may be expected over time as production volumes increase and experience is gained.⁴² Since 2009, the total cost to develop and build a utility-scale solar facility in the United States has dropped from over \$5 per watt to about \$1 per watt as of 2023.⁴³

⁴¹ Public Utility Regulatory Policies Act of 1978, Pub. L. No. 95-617, 92 Stat. 3117 (codified as amended in scattered sections of 16 U.S.C. and 15 U.S.C.). Known colloquially as PURPA.

⁴² Vatankhah Ghadim, H., Haas, J., Breyer, C., Gils, H. C., Read, E. G., Xiao, M., & Peer, R. (2025). Are we too pessimistic? Cost projections for solar photovoltaics, wind power, and batteries are over-estimating actual costs globally. *Applied Energy*, 390, 125856.
<https://doi.org/10.1016/j.apenergy.2025.125856>

⁴³ Lawrence Berkeley National Lab (2024). *Utility-Scale Solar, 2024 Edition: Empirical Trends in Deployment, Technology, Cost, Performance, PPA Pricing, and Value in the United States*.
<https://emp.lbl.gov/publications/utility-scale-solar-2024-edition>

This steady trend of cost reduction in utility-scale solar facilities construction and operation has improved the return on investment offered by solar projects.^{44,45} The above-referenced state credits have expired, with the federal credits set to expire in 2026⁴⁶ prompting a potential surge in development in advance of this policy change.⁴⁷

2. Local Decisions in Solar Development on Agricultural Land

While federal policy - general economic, tax, international trade and domestic resource development and environmental protection - shapes

⁴⁴ Lazard (2025). *Levelized Cost of Energy+ Analysis—Version 18.0*. <https://www.lazard.com/media/eijnqja3/lazards-lc-oepius-june-2025.pdf>

⁴⁵ Seel, J., Mulvaney Kemp, J., Cheyette, A., Millstein, D., Gorman, W., Jeong, S., Robson, D., Setiawan, R., & Bolinger, M. (2024). *Utility-Scale Solar, 2024 Edition: Empirical Trends in Deployment, Technology, Cost, Performance, PPA Pricing, and Value in the United States*. Lawrence Berkeley National Lab. <https://emp.lbl.gov/publications/utility-scale-solar-2024-edition>

⁴⁶ Pub. L. No. 119-21 (July 4, 2025).

⁴⁷ Deloitte. (2025, October 29). 2026 Renewable Energy Industry Outlook. Deloitte Insights; Deloitte. <https://www.deloitte.com/us/en/insights/industry/renewable-energy/renewable-energy-industry-outlook.html>

Note: Source states that fixed-mount solar already out-competes natural gas combined cycle in many regions without credits, reinforcing viability despite credit phaseouts.

renewable energy development, the critical decisions regarding procurement (via renewable energy mandates in state law), siting (via local ordinance), and permitting (on a site by site basis) belong to the states, and by extension, local governments.⁴⁸ Thus, the focus on solar energy development lies at the intersection between the developer, the landowner, and the local authority (and the community it represents) which must approve and provide a permit for a solar PV facility to enter its construction phase. The discussion that follows assumes that the North Carolina Utilities Commission will continue to provide Certificates of Public Convenience and Necessity (CPCNs) for a number of projects that will meet Duke Energy's proposed and NCUC-ratified targets. For the most part, with the 2017 passage of HB589⁴⁹ which established the Competitive Procurement of Renewable Energy (CPRE) program, Duke Energy has chosen the general geographic locations in North Carolina where it will procure solar-generated electricity to achieve its IRP goals. That law also limited Duke Energy's "self-development" of solar PV facilities to 30%, leaving the field open to private developers to build out Duke Energy's projected procurement of renewable electricity.⁵⁰ Section 2.1 provides perspective on the landowner's decision

⁴⁸ Stokes, D. (2022). Renewable Energy Federalism. *Minnesota Law Review*, 106(4). <https://doi.org/10.24926/265535.4365>

⁴⁹ Codified as N.C. Gen. Stat. § 62-110.8 (2017).

⁵⁰ N.C. Gen. Stat. § 62-110.8(a)(4) (2017).

to sign an option to lease their parcel to a solar PV developer (an act prior to the developer's application for a CPCN for the proposed site) in the context of continued farm use. Section 2.2 will overview local government processes required for approval of the solar PV land use (considered light industrial) within the limits of its municipality or county, with a look at the various issues that communities, planning boards, and elected commissioners address along their deliberation path, and thus what a developer will need to competently and thoughtfully address in securing approval for construction of the site to proceed.

2.1 The Landowner's Decision: Evaluating Alternatives

As noted above, while Duke Energy does develop and own a number of solar PV facilities in North Carolina,⁵¹

⁵¹ Duke Energy. (2022, January 27). Duke Energy's solar portfolio grows in North Carolina with the addition of two new plants [Review of Duke Energy's solar portfolio grows in North Carolina with the addition of two new plants]. Duke Energy | News Center. <https://news.duke-energy.com/releases/duke-energy-solar-portfolio-grows-in-north-carolina-with-the-addition-of-two-new-plants>
Duke Energy to sell utility-scale Commercial Renewables business to Brookfield for \$2.8 billion - Duke Energy One Energy Services. (2023). Duke Energy One Energy Services. <https://energyservices.duke-energy.com/resources/duke-energy-to-sell-commercial-renewables-business-to-brookfield/>

the majority of solar PV facility development occurs on land leased from private landowners by private non-utility developers, with the solar PV generation, storage, and transmission components owned by a separate entity (e.g. the original developer and any later owner of the installed generating equipment and its valuable power purchase agreement with Duke Energy). This distinction is important to understand: the landowner - active farm operator or otherwise - grants permission for a separate entity to build out a solar PV facility on their land. Like any written grant of use to another by lease, the landowner relinquishes use, access, and control of the solar PV facility footprint according to the terms of the solar PV facility lease; the parcel owner does not relinquish their title to the ground occupied by the solar PV facility. The landowner continues to pay property tax on the value of the land, and the developer pays personal property taxes on the value of the solar PV facility components. As a practical matter, almost no landowner, save a municipality⁵² or a utility company,

Note: Under HB591, Duke Energy has developed approximately 40 facilities across North Carolina.

⁵² North Carolina Clean Energy Technology Center. (2020). *Community Solar in the Southeast Policy Landscape for Public Utilities*. https://nccleantech.ncsu.edu/wp-content/uploads/2020/09/State-Profiles_Community-Solar-for-the-Southeast-1.pdf

Note: One notable example is Fayetteville's facility in Cumberland County. See <https://www.faypwc.com/fayetteville-pwc-opens-ncs-first-municipal-community-solar-project/>

self-develops a utility-scale solar PV facility on a parcel of land they own.

In this white paper's discussion of the change in use from farming to solar PV generation, a note of preface regarding the distinction between farmer and landowner is appropriate. Whereas a farmer as user of a parcel of land to raise crops or animals for market may also hold title to that land, very often the farmer's business (the farm operation or firm) also relies on renting or leasing land owned by another to support the farm operation and its required levels of production to support the firm's production, storage and transportation asset portfolio (field equipment, on-farm grain storage, trucks etc.). In North Carolina, about 41% of land in farms is leased.⁵³ At various times, such assets are financed, representing serviceable debt.

According to the 2022 Census, farmers rented 3.3 million acres of land from other landowners,⁵⁴ representing 39% of

⁵³ U.S. Department of Agriculture , National Agricultural Statistics Service (2024). *2022 Census of Agriculture, Volume 1, Chapter 1: State Data, North Carolina, Table 77.* https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/North_Carolina/st37_1_077_077.pdf

⁵⁴ U.S. Department of Agriculture, National Agricultural Statistics Service (2024). *2022 Census of Agriculture, Volume 1, Chapter 1: State Data, North Carolina, Table 8.* https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/North_Carolina/

land in farm use.⁵⁵ It must be acknowledged that the farmer will likely not benefit from solar PV development on land they do not own, and it is not clear in the census statistics the extent to which an individual farm relies on tenancies or leaseholds to sustain their operation as a primary or secondary income source. Thus, the impact of lost tenure to a particular solar PV facility proposal is difficult to ascertain absent consideration of the economies of the particular farm firms affected. To say generally that farmers benefit from the higher lease rate a solar PV facility provides relative to their crop income would be misleading.

Likewise, while this white paper makes extensive reference and discussion to the dual use opportunity offered by agrivoltaics, one must not assume that the farmer who has relinquished a rented field may pivot to the scale or type of production offered by a particular agrivoltaic opportunity allowed by the solar PV developer, nor is the farmer impacted by the particular solar PV development in control of accessing such opportunity. While commercially-viable, non-demonstrative agrivoltaics may have positive macroeconomic benefit, the micro-economic opportunity relative to individual farm firms is more difficult to

⁵⁵ Ayoub, S. (2025). *Agricultural Land: To Own or To Rent?* American Farm Bureau Federation. <https://www.fb.org/market-intel/agricultural-land-to-own-or-to-rent>

discern. There is much ongoing and evolving study of utilizing dual use opportunities, and the authors acknowledge that agrivoltaics - however promising - has limits as an immediate or available solution to a reduction in the current acreage relied on by individual farm firms.

2.1.1 Income Stream from the Solar Lease

Photovoltaic facility leases may extend out to 40 years. Solar PV facility leases are often protected by strict non-disclosure agreements (NDAs), making composite study on typical lease duration difficult beyond the anecdotal. That said, most solar PV leases are likely near a 25-year initial term because of the effective production warranty on current solar panel technology, which is typically 25 years.⁵⁶ Following the 2021 passage of the Energy Solutions for North Carolina Act (“HB591”), utility-scale solar projects are required to have a minimum 20-year power purchase agreement (PPA) with a public electric utility providing retail electric service in North Carolina.⁵⁷ This initial term is

⁵⁶ Clean Energy Reviews. (n.d.). *Solar panel warranty explained*. CLEAN ENERGY REVIEWS. Retrieved November 10, 2025 from <https://www.cleanenergyreviews.info/solar-panel-warranty>

Note: Such an initial term is confirmed by authors’ observation of lease templates shared by developers.

⁵⁷ S.L. 2024-37 (N.C.), N.C.G.S. §62-126.8B(a)(1)

often followed by several optional 5-year extensions - exercisable by the current owner of the solar PV facility (and its ground lease) - to continue use of the site with replaced panels. Also because of lease NDAs, specific lease rates are not publicly reported, though evidence suggests a range up to \$1,500 per acre per year.⁵⁸ (Another anecdotal estimate places the range between \$750 and \$1,400 per acre per year).⁵⁹ Because solar PV facilities are often built on parcels owned by different landowners, developers have an understandable business interest in keeping such negotiations private. The development path of a solar PV facility first requires securing the option to develop from the landowner to secure the land during the due diligence phase (e.g. securing PPA, local permitting, financing) - with the full lease terms attached to the option and negotiated prior to the signing of the option. The landowner can expect a potential 40-year commitment with their very first signature.

⁵⁸ Zahn, S. E. (2025, February 4). *Purdue University-CME Group Ag Economy Barometer*. Ag Economy Barometer. <https://ag.purdue.edu/commercialag/ageconomybarometer/u-s-farmers-retain-optimistic-outlook-for-2025-despite-ag-trade-uncertainty/>

⁵⁹ Moore, J. (2016). *Solar and Wind Energy Development Opportunities: Tax Implications*. Ncsu.edu. Retrieved November 10, 2025 from <https://www.ces.ncsu.edu/solar-and-wind%20energy-development-opportunities-tax-implications/>

As far as the income stream from the solar leasehold, as noted above, exact payment structures and per acre payment amounts are difficult to obtain, but generally follow a consistent pattern.⁶⁰ Given the range suggested above, it is fairly easy to estimate the net present value of the solar PV lease over its term, including option periods. All solar PV leases begin with an option period where the landowner is paid a nominal sum that gradually increases as the option period is extended over several increments (e.g. 180 days, 360 days, etc.) until the developer either begins construction or allows the option to expire (abandons the project). The full per-acre annual payment (e.g. \$700, \$850, \$1000) generally starts at construction and runs through to the end of contract term or any renewal option periods (generally a succession of five-year options renewed at owner's election), usually with negotiated percentage increases, which one may presume factors in future inflation and land value appreciation. The income stream from the lease is variable with acreage, but easily calculated as a no-cost (net) payment before taxes, based on acreage, rate per acre, and annual increase in rate per acre. Application of a net-present value

⁶⁰ Veldman, R., & Shambaugh, Q. (2025, October 29). *Navigating and Negotiating Renewable Energy Leases*. American Solar Grazing Association. Retrieved November 10, 2025 from <https://solargrazing.org/event/navigating-and-negotiating-renewable-energy-leases/>

percentage to future lease payments can provide a landowner a comparison with the opportunity to simply sell their parcel to another type of development, including continued farm use by the purchaser.

2.1.2 Solar Lease as Term-Limited Use

By definition, a lease is a term-limited lawful right of possession granted to another by the owner of property. Modern solar facilities are similar to other long-term ground leases for non-farm use, and like any ground lease - say for a distribution warehouse - once the lease term expires, the land may in theory return to its state (and perhaps use) prior to development if the lease structure is removed. Indeed, it is common practice in lease negotiation that the lessee remove its property at the end of term. However, unlike other ground lease uses, solar PV facilities are required to be removed by law. North Carolina is one of the earliest states to mandate removal and restoration of parcels of land used for solar PV development, a process called decommissioning.

As explored below, North Carolina's decommissioning policy mandates a facility owner obligation to remove solar PV equipment from the parcel, and that financial assurance be made and continually updated to cover the

costs of restoring a parcel to its original “undeveloped” state.⁶¹ South Carolina’s decommissioning policy has parallel mandates for removal and financial assurance to cover “reasonable” land restoration.⁶² Whether the parcel returns to active agricultural (or managed commercial timber) use depends on the desires and needs of the parcel owner at that future point in time (e.g. 25 to 40 years hence, which may be a lineal descendant or unrelated transferee of the landowner/lessor). Whether a parcel may immediately return to productive farm use following decommissioning depends on various - albeit potentially short-term - factors such as restoration of any removed topsoil during initial development, compaction, change in soil pH, and potential non-supply of nutrients (e.g. fertilizer, manure, etc.) during solar PV use. Thus, unlike most commercial and *all* residential development, which normally requires a transfer of ownership signalling a permanent land use change, solar PV development - given its leasehold term-limit and (in states including North and South

⁶¹ Note that the original “undeveloped” state may be cropland classified as “prior converted wetland” under the Food Security Act of 1985 (Pub. L. No. 99-198, 99 Stat. 1354 [1985]), where a change in use to solar facility will terminate landowner agricultural benefits under that law. Certain soils (e.g. organic and mineral) may be prone to re-inundation to the point of a wetland reclassification (potentially triggering jurisdiction of other agencies), so site owners must remain vigilant in maintaining existing drainage systems.

⁶² S.C. Code Regs. §61-107.20 (2024).

Carolina) a statutory mandate for decommissioning and land restoration - is by definition a temporary land use, albeit one that may be continued by further agreement and regulatory approval.

Beyond the assurance of the decommissioning mandate, there is the question of whether the use of the existing footprint of the facility will continue beyond the initial lease term and extension options, and to what extent these may themselves expand in acreage.⁶³ There is growing discussion and study on the economics of **repowering** existing sites. Under present economics, repowering an existing site is 10% to 30% more expensive than new “greenfield” development.⁶⁴ While it is very difficult to predict real estate markets for solar and non-solar use 25 to 40 years into the future, it may be that the future economics of solar facilities support the idea that a number of the projects built today - with planned upgrades - become more efficient and profitable by gained efficiencies in solar panel technology at a later time, thus allowing

⁶³ Curtis, T., Heath, G., Walker, A., Desai, J., Settle, E., & Barbosa, C. (2021). *Best practices at the end of the photovoltaic system performance period*. National Renewable Energy Laboratory.

<https://www.nrel.gov/docs/fy21osti/78678.pdf>

⁶⁴ Ovaatt, S., Mirlitz, H., Mirlitz, B., Prilliman, M., & Barnes, T. (2024). SIPS on “PV Repowering”: Quantifying the Impact of PV System Repowering and Module Reuse on PV Project Economics, Sustainability, & Equity.

<https://www.nrel.gov/docs/fy25osti/91745.pdf>

for greater incentives to landowners to keep their parcels in solar use. It is possible that such parcels with a built interconnection to the electric grid gain value for continued solar PV use. Opportunity for renewal would require a renegotiated lease, perhaps a purchase of the ground by the owner of the facility from the landowners then living. And though pure conjecture, policy may even develop - as it does in all land use matters - to incentivize repowering and continued use of solar PV facilities, perhaps to reduce the cost and need of developing other land. Though this idea counters the above assertion that solar facilities are temporary, such continued use may negate a need to devote more acreage to more facilities, in effect mitigate the upward trend of acquiring more acres for solar PV use.⁶⁵ While this counters any assurances to concerned local stakeholders that a converted farm use parcel will return to farm or some other use after the initial lease negotiated prior to construction of the facility expires, decommission and restoration remains a safe assumption for the future, and thus an objective consideration in county land use decisions.

⁶⁵ Bolinger, M., & Bolinger, G. (2022). Land Requirements for Utility-Scale PV: An Empirical Update on Power and Energy Density. *IEEE Journal of Photovoltaics*, 12(2), 589–594. <https://doi.org/10.1109/JPHOTOV.2021.3136805>

2.1.3 Retained Wealth: Valuation of the Parcel Hosting Solar PV

Because ownership of land used in solar PV stays with the grantor of the lease (i.e. the landowner), the land represents retained and appreciating wealth. The land subject to the lease may be sold to a new owner, and may be gifted to or inherited by descendants of the current owner. It is legally possible for a landowner to sell a parcel to a new owner even while retaining the income stream from the lease (much like a retained mineral or timber right); how often this is done is not known without targeted research by county and facility, but the land would likely sell at some discount considering full use would not be available until expiration of the present leasehold. Regardless, evidence suggests value to the community in the form of increasing property taxes from parcels supporting PV facilities.

One public measure of increase in value of the underlying parcel may be found by examining the periodic revaluations commissioned by tax assessors at such intervals when all land parcels are reviewed.

For example, though somewhat dated figures, the chart below nonetheless demonstrates a reappraisal by a county tax office (Orange County, North Carolina) by appraisers licensed to practice in North Carolina:

Year	Land Use Classification: Forestry				Land	
	Value (Highest and Best Use)	Value (PUV)	Tax (PUV)	Tax (Rollback)	Value	Tax (Paid by Landowner)*
2012		\$ 9,034.00	\$ 85.64			*fluctuations may reflect interest accrued at time of payment
2013	\$ 207,777.00	\$ 9,034.00	\$ 85.64	\$ 2,130.20		
2014	\$ 207,777.00	\$ 9,034.00	\$ 85.64	\$ 2,130.20		
2015	\$ 207,777.00	\$ 9,034.00		\$ 2,238.29		
2016	Year of Development				\$ 166,200	
2017					\$ 130,100	\$ 1,178.06
2018					\$ 130,100	\$1,194.58
2019					\$ 130,100	\$1,217.35
2020					\$ 130,100	\$1,217.35
2021				2021 County Reappraisal	\$ 130,100	\$1,159.84
2022					\$ 130,100	\$1,189.11
2023					\$ 130,100	\$1,220.47
2024					\$ 130,100	\$1,256.37
2025				2025 County reappraisal	\$397,500	\$2,870.35

In the example above - a conversion of a forested parcel to solar PV use - the underlying parcel (35 acres +/-) suffers a drop in value from predevelopment value of \$207,777 to post development value of \$130,100 that holds until a later scheduled reappraisal (2025) where the parcel is revalued at \$397,500.⁶⁶ One caveat is that county revaluations employ mass appraisals based on generalized changing conditions in localized areas, whereupon a change variable is applied to multiple parcels, rather than in-depth review on a parcel by parcel basis.⁶⁷ (Further discussion of land valuations affected by a solar PV facility is explored below).

2.1.4 Impact on Farm Tenant/Lessee and Local Farm Economy

For the landowner who also produces farm products on their land (i.e. the

⁶⁶ Orange County, North Carolina. (2025). *Orange NCGIS*. Orange County, North Carolina. <https://gis.orangecountync.gov/orangeNCGIS/default.htm>

Note: Examination by authors of parcel number 9844172687 Orange County on November 11, 2025. GIS profiles link to property tax history.

⁶⁷ 2025 Property Revaluation & Resources | Orange County, NC. (2025). *Orangecountync.gov*. Retrieved November 19, 2025 from <https://orangecountync.gov/878/Revaluation>

Note: Analysis states that, "our appraisers analyze market data, including recent arms-length market sales, income/expense information (for income producing properties), construction costs, and other property characteristics, to estimate what each property would likely sell for as of January 1, 2025."

farmer who owns the land they farm), the tradeoff in benefit of conversion to solar PV facility use may be a consideration of that farm's prospects for continued farm use in the next generation, and the extent to which a successor family operator relies on farm income from that converted parcel of land to continue farm operations at a sustainable level. This may include the extent the financial returns from the solar PV lease ameliorates any future loss of farm income (less the avoided costs of that farm production), and to what extent the lease income financially supports the successor who has chosen to devote their primary income-earning efforts to farming (especially when lease income is shared with other family members). On a per-acre basis, the evidence shows a higher solar PV lease payment than farm rent for those soils in any particular part of the state.⁶⁸ For the farmer/landowner, the calculation is the profit from active farming measured against the passive solar PV lease payment, the latter likely higher for most available production regimes. A decision is made whether to acquire more rented land or scale back operations, perhaps driven by the financial exigencies of debt service on production assets (e.g. farm equipment).

⁶⁸ Moore, J. (2015). *Solar and Wind Energy Development Opportunities: Tax Implications*. NC State Extension. <https://www.ces.ncsu.edu/solar-and-wind-energy-development-opportunities-tax-implications/>

For both the farmer/landowner and the farmer tenant/lessee, the impact of the solar PV lease to the farm firm depends on the remaining land (owned and rented) that farm firm has access to in the area. Much depends on the stability of the other farm firms operating in the area, and the extent to which they also compete for rented agricultural land. These decisions surely depend on factors other than financial, including a strong desire to continue a family farm in a succeeding generation.

Appreciating the aggregate financial impact of land use change (out of farm use) to the surrounding farm support economy - including elevators and distributors, equipment dealers and input suppliers, etc.) needs further study. The concern is certainly logical: for each acre of farm product removed, there is a corresponding reduction in the volume of product from that acre delivered to the local distributor (e.g. a cotton gin, a grain elevator, etc.), and such concerns are expressed at public hearings on zoning ordinance changes regarding solar siting and permitting, or quasi-judicial special use permit hearings.⁶⁹

⁶⁹ Branan, R. (2025, April 21). *Solar Development: Testimony Sketches from a County Hearing on Ordinance Changes*. N.C. Farm Law. <https://farmlaw.ces.ncsu.edu/2025/03/solar-development-sketches-from-a-county-hearing-on-ordinance-changes/>

As regards to the financial impact on the single producer, a relatively straightforward calculation may be made on behalf of the farm tenant or lessee of land that is being converted to solar PV facility use. As noted, the financial benefits of the solar PV lease are not necessarily shared with producer-tenants, who simply lose the yield and market benefit of that particular acreage. Although there are avoided costs to the lost production (e.g. rent and inputs such as seed, fertilizer/herbicide, fuel, time), the lost income may impact the fixed carrying costs such as loan repayment for equipment and other land. For this calculation, one may look to the farmer's historic yields from that particular parcel (e.g. as reported to the Farm Service Agency [FSA] for support program qualification),⁷⁰ or by researching tools that reveal realistic yields.⁷¹

As farm communities address such real challenges, there is growing interest in the concept of mitigation for the change in use of farmland to solar PV facilities, with the understanding that such converted land likely cannot be presently replaced on an acre by acre basis for farm use in that vicinity.

⁷⁰ 7 C.F.R. § 718.102 (2025) (requiring acreage reports as a condition of eligibility for most USDA programs).

⁷¹ North Carolina Interagency Nutrient Management Committee. (2014). *Realistic Yields*. NC State Extension. Retrieved November 12, 2025 from <https://realisticyields.ces.ncsu.edu/>

In most areas of North Carolina, the available land with productive soils and drainage infrastructure is already being farmed and has been for some time, with other unproductive undeveloped lands lying fallow with unmanaged vegetation growth, in managed forest, or wetlands. In other words, there is no unused reserve, and conversion from unmanaged forested land to tillable cropland is cost prohibitive, and wetland areas are no longer drained as a matter of farm support policy (e.g. Swampbuster)⁷² and protection under the Clean Water Act (Section 404, discussed below). That said, the search for mitigation might be addressed by protecting other farm lands from future change in use through use of conservation easements. Some counties (e.g. Chatham)⁷³ in North Carolina have begun to devote the property tax collected due to change in use under North Carolina's Present Use Property tax program to local funds that match other state and federal funds for purchase of development rights on lands with productive soils. While not

⁷² Agriculture Improvement Act of 2018, Pub. L. No. 115-334, § 2102, 132 Stat. 4490 (2018). Note: Farm producers become ineligible for farm support and conservation payments if they cannot certify that they have not converted wetlands prior to 1986.

⁷³ Chatham Agricultural Preservation & Development Trust Fund | Chatham County, NC. (2024). Chathamcountync.gov. <https://www.chathamcountync.gov/government/departments-programs-i-z/soil-water-conservation-district/farmland-preservation/chatham-agricultural-preservation-development-trust-fund>

directly tied to solar PV development permissions and certainly not an acre for acre solution, such a mitigation measure may at least ensure further farmland protection against change in use due to solar PV development or any other industrial or residential conversion. Regarding planning to influence siting - discussed below - some North Carolina counties are considering development ordinance changes to balance solar PV facility permitted use with protection of resources such as farmland soils.

2.1.5 Considering Dual Use: Agrivoltaics

The unavoidable cessation of full scale agricultural use of a parcel that has been developed for solar electricity generation understandably raises the concern that the productive farmland parcel no longer supports individual, county and state farm economies. As noted throughout this paper, concern over farmland loss is a focal point of local and regional concern. For this and likely other reasons, much effort is being devoted to proving that solar PV development need not extinguish agricultural use of a parcel for the life of the solar lease. Such focus has introduced the new term *agrivoltaics*.

Agrivoltaics touch on the human pillars of solar PV development - facility owner, community, landowner, farmer - in different ways. An increasing body of research is being devoted to the exploration of socio-economic impacts in the local community to better understand agrivoltaic systems, with investigations concerning economic viability to the producer, maintenance cost-savings to the solar PV owner, landowner involvement, and the scalability of such systems.

The body of research on the projected aggregate agricultural economic impact of state renewable energy targets is in its infancy. However, the immediate impact to individual producers losing leased fields to solar development is easily measured in lost production acres, and such individuals often retain significant voice and goodwill in the community. The growing body of policy work on decommissioning of solar facilities - i.e. the promise that one day the land may be farmed - may fail to address short term concerns.

Given the present economic limitations between prevalent low-to-ground technology and panel spacing, continued agricultural production options - and agricultural economic output - remain limited. The study of agrivoltaic systems is global on a variety of crops and solar panel spacing to

achieve different results.⁷⁴ According to the National Laboratory of the Rockies (NRL) [OpenEI Agrivoltaics Map](#), there are 635 dual-use solar facilities covering 84,611 acres and generating 13,678 MW of electricity in the United States.⁷⁵ (Authors are aware of sites in North Carolina that are undocumented on the NRL map). A number of studies in the United States have documented research of various crops, including blueberry production in Maine (2024)⁷⁶ and cherry tomatoes in Oregon (2021).⁷⁷ The majority of functioning solar PV facilities are devoted to pollinator habitat production, with the next predominant agricultural use of sheep grazing.⁷⁸ Limited United States markets for sheep meat and wool may serve as a

⁷⁴ Al Mamun, M. A., Dargusch, P., Wadley, D., Zulkarnain, N. A., & Abdul Aziz, A. (2022). A review of research on agrivoltaic systems. *Renewable & Sustainable Energy Reviews*, 161, 112351.

<https://www.sciencedirect.com/science/article/pii/S1364032122002635?via%3Dihub>

⁷⁵ OpenEI. (n.d.) *InSPIRE/Agrivoltaics Map*. Retrieved November 9, 2025, from

https://openei.org/wiki/InSPIRE/Agrivoltaics_Map

⁷⁶ L. Calderwood. (2024). *Investigating Dual-Use Solar for Wild Blueberry Farms in Maine*, SARE Grant Project Report. Sustainable Agriculture Research and Education.

<https://projects.sare.org/project-reports/Ine22-448r/>

⁷⁷ Al-agele, H. A., Proctor, K., Murthy, G., & Higgins, C. (2021). A case study of tomato (*Solanum lycopersicon* var. Legend) production and water productivity in agrivoltaic systems. *Sustainability*, 13(5), 2850.

<https://www.mdpi.com/2071-1050/13/5/2850>

⁷⁸ U.S. Department of Energy. (n.d.). *Agrivoltaics: Solar and Agriculture Co-Location*. <https://www.energy.gov/eere/solar/agrivoltaics-solar-and-agriculture-co-location>.

bottleneck to wider implementation of agrivoltaic grazing regimes, and site opportunities for grazing contracts may be misaligned with available grazing services, local producers, and processing.⁷⁹ The national leader in solar grazing efforts - American Solar Grazing Association (ASGA) - maintains its own map of agrivoltaic grazing sites.⁸⁰ ASGA produced a 2024 census counting near 62,000 sheep grazing over 87,000 acres at 109 solar sites in the South (with over half in Texas).⁸¹ From the landowner's perspective - if they are inclined and allowed to pursue sheep grazing in the leasehold - it may be possible to negotiate access and use of the ground in the solar lease or by separate agreement. A developer would likely wish to ensure that the landowner/sheep grazer had the requisite skill to maintain such an enterprise.

In addition to the growing body of experience in solar sheep grazing, a number of studies nationwide are experimenting with other production regimes which may be more aligned with current agricultural use. One illustration of this research is the soybean study released by the Rutgers Agrivoltaics Program, where Rutgers University (New Jersey) in 2025 reviewed first-year trials of soybean production amid two types of panel arrays in a north-facing orientation at the New Jersey Agricultural Experiment Station.⁸² In that study, researchers planted the soybean variety between panels spaced 34 feet in rows of 74 feet, with a 34 x 74 foot space serving as the windbreak between panel clusters serving as the control area. Researchers applied a pre-emergent herbicide in June 2024, and the beans were harvested in early November 2024 with several passes per row with a 5-foot header.

⁷⁹ Lydersen, K. (2025, September 11). Illinois farmers find that sheep and solar arrays go well together. *Canary Media*.

<https://www.canarymedia.com/articles/solar/illinois-farmers-graze-sheep-agrivoltaics>

⁸⁰ American Solar Grazing Association. (2023). *Solar Grazing Map*. Retrieved November, 2025 from <https://solargrazing.org/map/>

⁸¹ Andrew, A. C., Monlezun, A. C., Richardson, K., Owen Chase, B., Macknick, J., Plotkin, G., Armentrout, N., Hain, L., Barter, J., Campbell, K., Dotterer, D., Finnegan, D., Gray, J., Harrar, F., Owens, C., Raines, C., & Valdez, E. (2025). *United States solar grazing 2024 census*. American Solar Grazing Association. <https://solargrazing.org/us-solar-grazing-2024-census>

⁸² Wyendant, A., & Ward, D. (2025, July 9). *2024 agrivoltaics soybean harvest at RAREC in southern New Jersey*. Rutgers Agrivoltaics. <https://agrivoltaics.rutgers.edu/2025/07/09/2024-agrivoltaics-soybean-harvest-at-rarec-in-southern-new-jersey/>

The study found that soybean yield was higher in rows between the two panel array types (single panel and double panel) than in control rows with no solar panels. Also, protein and oil content did not differ significantly between control plot and panel plots; moisture content difference was not significant (showing 13% in control plot).⁸³ Cornell University produced a similar study.⁸⁴

Federal and policy efforts support agrivoltaics research and development. The DOE's Foundational Agrivoltaic Research for Megawatt-Scale (FARMS) program has awarded funding to examine how agrivoltaics can provide new economic opportunities to farmers, rural communities, and the solar industry.⁸⁵ Several states have added complementary programs and competitive grants to accelerate local demonstrations and outreach—for example, Colorado's Agrivoltaics Research and Demonstration Grant Program and New York's NYSERDA

agrivoltaic demonstration projects—to better understand the costs, benefits, and market potential for agrivoltaics.^{86,87,88} Other states including Maryland and Nevada have established additional tax incentives to incentivize agrivoltaic systems.⁸⁹ Additionally, previously proposed federal legislation (S. 1778, the Agrivoltaics Research and Demonstration Act of 2023) would have directed the USDA to study agrivoltaics, create a five-year research and demonstration plan, and establish regional demonstration sites if enacted.⁹⁰ N.C. State University established its first agrivoltaic research facility in November 2025.⁹¹

⁸³ Wyendant, A., & Ward, D. (2025, July 9). *2024 agrivoltaics soybean harvest at RAREC in southern New Jersey*. Rutgers Agrivoltaics. <https://agrivoltaics.rutgers.edu/2025/07/09/2024-agrivoltaics-soybean-harvest-at-rarec-in-southern-new-jersey/>

⁸⁴ Friedlander, B. (2023, March 1). *Made in the shade: Growing crops at solar farms yields efficiency*. *Cornell Chronicle*. <https://news.cornell.edu/stories/2023/03/made-in-the-shade-growing-crops-solar-farms-yields-efficiency>

⁸⁵ U.S. Department of Energy. (n.d.). *Foundational Agrivoltaic Research for Megawatt-Scale (FARMS) funding program*. <https://www.energy.gov/eere/solar/foundational-agrivoltaic-research-megawatt-scale-farms-funding-program>

⁸⁶ Colorado Department of Agriculture. (n.d.). *Agrivoltaics grants*. <https://ag.colorado.gov/conservation/agrivoltaics-grants>

⁸⁷ New York State Energy Research and Development Authority. (2024, June 7). *\$5 million available for agrivoltaic demonstration projects*. https://www.nyserda.ny.gov/About/Newsroom/2024-Announcements/2024_06_07-NYSERDA-Announces-5-Million-is-Now-Available-For-Demonstration

⁸⁸ New York State Energy Research and Development Authority. (2025, November 5). *Over \$7 Million Awarded To Co-Locate Solar and Agricultural Operations in New York State*. <https://www.nyserda.ny.gov/About/Newsroom/2025-Announcements/2025-11-05-NYSERDA-Announces-Over-7-Million-Awarded-To-Co-Locate-Solar-And-Agricultural-Ops>

⁸⁹ National Caucus of Environmental Legislators. (September 2023). *Agrivoltaics Fact Sheet*. <https://www.ncelenviro.org/resources/agrivoltaics-fact-sheet/>

⁹⁰ S.1778 Agrivoltaics Research and Demonstration Act of 2023.

⁹¹ N.C. State Clean Energy Tech. Ctr. (2025, November 20). *NC State and Nevada Launch New Agrivoltaics Training Site; Solar Training Site Is the First of Its Kind in the Southeast*. <https://nccleantech.ncsu.edu/2025/11/20/nc-stat>

Regarding community support, one study from Pascaris, A.S et al., suggests that agrivoltaic development may directly reduce friction during zoning hearings.⁹² The study found that “81.8% of respondents [to a survey] would more likely support solar development in their community if it integrated agricultural production.” As noted in this white paper, continuing research into statewide and community agricultural economic impacts is needed, as are the likely economic compromises and policy incentives required for scalable and high-value agricultural output to address concerns over farmland loss, particularly the efficiencies of large field row-crop production more suitable for modern wide-planting and harvesting equipment.

2.2 Addressing Concerns About Agricultural Impact in Permitting Decisions

Beyond state-level procurement and siting policy identified in Section 1.2 above - allowing a particular solar PV site to proceed to construction is a matter of local authority, where decisions about private land use are made in the crucible of community

[e-and-nevados-launch-new-agrivoltaics-training-site-solar-training-site-is-the-first-of-its-kind-in-the-southeast/](https://doi.org/10.1007/s44173-022-00007-x)

⁹² Pascaris, A. S., Schelly, C., Rouleau, M., & Pearce, J. M. (2022). Do agrivoltaics improve public support for solar? A survey on perceptions, preferences, and priorities. *GRN Tech Res Sustain*, 2, 8. <https://doi.org/10.1007/s44173-022-00007-x>

preferences. Throughout the American 20th century, the establishment of local (municipal and county) zoning regimes has continued to separate land uses considered incompatible, often for economic reasons to protect property values and offer relatively unmolested use by businesses and residences. Such zoning regulation has long been accepted as a lawful exercise of a state’s (and thus local government’s) *police power*, provided such regulation follows a plan.⁹³ Police Power is defined by the famous Black’s Law Dictionary as “[t]he power of the state to place restraints on the personal freedom and property rights of persons for the protection of the public safety, health, and morals or the promotion of the public convenience and general prosperity.”⁹⁴ Such police powers manifest as restrictions under a unified zoning ordinance, as well as environmental restrictions (e.g. local land disturbance sedimentation ordinances).⁹⁵ Alongside zoning are state common law theories of nuisance and trespass to disincentivize any harmful impact a parcel user may impose upon neighboring parcels.

Zoning authority naturally impacts free use of real property. Private property rights and freedom of use are protected from government interference under the

⁹³ *Vill. of Euclid v. Ambler Realty Co.*, 272 U.S. 365 (1926).

⁹⁴ Black’s Law Dictionary 468 (5th ed. 1979).

⁹⁵ See N.C.G.S. § 113A-50 et seq.

United States Constitution’s Fifth Amendment (known as the “Takings Clause”) as well many federal cases, particularly the United States Supreme Court, concerning federal, state and local land regulation.⁹⁶ North Carolina likewise follows this principle under its constitution’s “law of the land” clause,⁹⁷ and regulation of land resources has largely remained a matter of state law for two centuries. The North Carolina Supreme Court in 2024 reiterated North Carolina’s common law tradition favoring the free and unrestricted use of real property.⁹⁸

Under this balanced framework, the state, local, and federal governments can encourage or discourage specific

⁹⁶ The US Supreme Court has weighed in on a number of disputes to define when regulation defies the 5th Amendment takings clause, see *Pa. Coal Co. v. Mahon*, 260 U.S. 393 (1922) (recognition of the concept of regulatory taking); *Penn Cent. Transp. Co. v. N.Y. City*, 438 U.S. 104 (1978) (establishment of a test to determine regulatory takings); *Lucas v. S.C. Coastal Council*, 505 U.S. 1003 (1992) (regulatory deprivation of all economic use); and *Nollan v. Cal. Coastal Comm’n*, 483 U.S. 825 (1987) and *Dolan v. City of Tigard*, 512 U.S. 374 (1994) (each concerning conditions placed on permitted development [“exactions”])

⁹⁷ NC Constitution Article I, Section 19

⁹⁸ See *Schooldev E., LLC v. Town of Wake Forest*, 386 N.C. 775, 899 S.E.2d 589 (2024). “The public policy of North Carolina encourages “the free and unrestricted use and enjoyment of land.” Kirby v. N.C. Dep’t of Transp., 368 N.C. 847, 852 (2016) (cleaned up). This policy advances our state’s enduring commitment to property rights. See *id.* at 852–53 (“The fundamental right to property is as old as our state.” (citing N.C. Const. of 1776, Declaration of Rights § XII; Bayard v. Singleton, 1 N.C. (Mart.) 5, 9 (1787))”

landowner choices through regulation as well as incentives favoring particular uses. Absolute “freedom” to use property as one wishes is bound by various forms of regulation in the exercise of the state’s inherent “police power” to regulate the general health and welfare.

2.2.1 The Solar PV Permitting Process: Special Use Permits, Ordinance Changes, and Public Input

Following interconnection approval of a proposed facility by the NCUC (i.e. CPCNs), and the securing of a PPA with a retail utility (e.g. Duke Energy), the primary approvals for construction are administered by county and municipal governments. The two primary permits required are a) a special use permit (SUP) to allow the light industrial use in an otherwise non-industrial area, and b) a stormwater/sedimentation control permit (discussed below under Erosion and Vegetation Management).

As far as federal permitting, the principal statute involved in siting and development is the Federal Water Pollution Control Act of 1972 (the Clean Water Act). The relevant permit is a Section 404 Clean Water Act permit (404 permit) for projects that will impact (e.g. discharge dredge and fill material into) wetland areas that are considered jurisdictional under that federal law and

its supporting regulations.^{99,100} Also relevant to this permitting is the Endangered Species Act, requiring evaluation of possible impacts on habitat relied on by listed species.¹⁰¹ Note that the Army Corps of Engineers - which administers Section 404 permitting - operates under a Nationwide Permit 51, which streamlines elements of permit approval for land-based renewable energy facilities.¹⁰² Note that - in regard to isolated wetlands not considered jurisdictional under the Clean Water Act - North Carolina has removed permit requirements for the alteration of such wetland areas.¹⁰³ Depending on facility location - for example an area under jurisdiction of North Carolina's Coastal Area Management Act - other agency permitting may be required.

⁹⁹ Protection of Environment, 40 C.F.R. § 230 (2025). <https://www.ecfr.gov/current/title-40>

¹⁰⁰ Navigation and Navigable Waters 33 C.F.R. §§ 320–330 (2025).

<https://www.ecfr.gov/current/title-33>

¹⁰¹ Endangered Species Act of 1973, 16 U.S.C. §§ 1531–1544. Specifically, 16 U.S.C. § 1536(a)(2) (known as “Section 7”) requiring consultation with U.S. Fish and Wildlife Service regarding potential listed species impact of federal decisions, including permits.

¹⁰² Nationwide Permit 51—Land-Based Renewable Energy Generation Facilities, 86 Fed. Reg. 2744 (Jan. 13, 2021). Note this permit expires on March 14, 2026. The permit notice may be accessed at:

<https://www.swt.usace.army.mil/Portals/41/docs/missions/regulatory/2021%20NWP/2021%20nwp-51.pdf>

¹⁰³ See N.C. Sess. Laws 2023-63 (S.B. 582) (titled "North Carolina Farm Act of 2023"), directed a revised definition of wetlands found in 15A NCAC 2B 0202.

In North Carolina, county and municipal governments are authorized to enact zoning ordinances to regulate land use, keeping incompatible uses separated.¹⁰⁴ While neither are required to do so, all municipalities and most counties have some measure of zoning (though there remain some areas in North Carolina counties not currently zoned). County zoning ordinances are codified as a Unified Development Ordinance (UDO), with a grid of land uses (e.g. residential, commercial, industrial, etc.) where solar PV facilities - generally considered “light industrial” - are either allowed by special use permit, or not included as a permitted use (disallowed outright). (Some county ordinances may allow solar PV facilities in a light industrial zone without permit; such areas have not been identified for this paper.) A growing number of counties have revised or are considering revising their ordinances with specific provisions concerning solar PV development.¹⁰⁵

Special use permit decisions are a public process, with mandatory allowance for input from those directly impacted by the project to express their views either for or against the permit in what is known as a quasi-judicial action.¹⁰⁶ In such proceedings, members

¹⁰⁴ N.C. Gen. Stat. § 160D-702.

¹⁰⁵ Lovelady, A. (2014). *Planning and zoning for solar in North Carolina*. UNC School of Government.

https://www.sog.unc.edu/sites/default/files/full_text_books/pandzsolar2014.pdf

¹⁰⁶ See NCGS § 160D-406

of the public impacted by the project - known as having “standing” - may present evidence at such hearings in support or opposition to the special use permit.¹⁰⁷ Though not required, counties are known to host public input sessions prior to any such permit hearings for more general input on the general pros and cons of a solar PV development in their community, often addressing proposed changes in the county zoning ordinance regarding such facilities. One such example of a public input session was held in Warren County, North Carolina in November 2025.¹⁰⁸

In permitting decisions, the county board of commissioners is held to certain standards outlined by the North Carolina Supreme Court, whereby a solar PV developer can present a *prima facie* case for approval upon presentation of evidence that the project will not harm public health and safety. The four elements of the *prima facie* case are: 1) the use **will not materially endanger the public health or safety** if located and developed according to the plan as submitted and approved); 2) the proposed project is **in compliance with the existing zoning ordinance** (i.e. the use meets all required conditions and

¹⁰⁷ Standing is required by N.C.G.S. §160D-406 and defined in N.C.G.S. 160D-1402(c), generally those with an ownership, option, or leasehold in the parcel at issue.

¹⁰⁸ Weldon, L. (2024, August 15). Town council considers zoning ordinance amendments. *The Warren Record*. https://www.warrenrecord.com/news/article_c9329457-80fb-4bcf-9996-d12950bd38d0.html

specifications of the zoning ordinance); 3) the proposed project **does not damage property values** (i.e. the use will not substantially injure the value of adjoining or abutting property, or the use is a public necessity); and 4) the proposed use is in **harmony and conformity with the surrounding area** (considered are whether the location and character of the use, if developed according to the plan as submitted and approved, will be in harmony with the area in which it is to be located and in general conformity with the comprehensive plan of the local government).¹⁰⁹ Permit approvals or denials are appealable to county superior court, and further to the North Carolina Court of Appeals, which over the years has issued a number of decisions regarding matters concerning the county’s decision and the sufficiency of evidence considered in such decisions.¹¹⁰

As of November 2025, a number of North Carolina counties are developing various processes of public input and incorporation of such input to update their zoning ordinances regarding siting and permitting. For example, the Edgecombe County planning department in 2025 initiated a

¹⁰⁹ See *Kenan v. Bd. of Adjustment*, 281 N.C. 314, 188 S.E.2d 897 (1972)

¹¹⁰ For example, see *Dellinger v. Lincoln County*, 266 N.C. App. 275, 832 S.E.2d 172 (2019); *Coastal Pine Solar, LLC v. Pender County*, No. COA24-108 (N.C. Ct. App. Dec. 31, 2024), *withdrawn by order of the court on Jan. 17, 2025*.

stakeholder input process for consideration of various ordinance changes including vegetative buffer requirements, facility size limitations, wildlife management standards, farmland mitigation, and whether to create a conditional zoning approach to such facilities.¹¹¹ That said, a legislative change inserted in the Hurricane Helene recovery bill (SB382) though unrelated to the recovery, has limited county ability to “down zone” zoning districts identified in their UDOs, where a county is currently unable to render a present permitted use a non-conformity.¹¹² This effectively removes a county’s authority to remove the solar PV facility use already allowed as a conditional use (subject to special use permit process) in UDO zoning districts. This limitation may be subject to future state policy change.

Regarding conditional zoning: a county may revise its ordinance (through required legislative process) to incorporate a conditional zoning approach to permitting solar PV facility development in which “site plans or individualized development conditions are imposed.”¹¹³ Such an approach requires all owners of a parcel or parcels

¹¹¹ Branan, A., Meadows, C., Spell, D., & Weitz, A. (2025, October 15). *Planning at the speed of solar: Collaborative approaches to renewable energy ordinances in the Carolinas* [Conference presentation]. APA-NC/SC Planning Conference, Charlotte, NC.

¹¹² S.L. 2024-57, s. 3K(a) (amending N.C. Gen. Stat. §160D-601(d) (effective Dec. 11, 2024).

¹¹³ N.C.G.S. §160D-703(a)(2).

of property under consideration to petition the county for conditional zoning approval which may allow more flexibility than the special use permit process identified above in regards to development conditions regarding matters including impact fees and design elements.¹¹⁴ Current down zoning prohibitions identified above may limit this approach.



2.2.2 Addressing Local Concern, Part I: Research on the Impact of Solar PV Development on Land Otherwise Available for Agricultural Production

According to a 2024 study by the USDA Economic Research Service (ERS), most solar PV facilities were installed on land that was used for crops or pasture in rural areas between 2009 and 2020, revealing an estimated footprint of solar farms in the U.S. in that period of about 336,000 acres,

¹¹⁴ N.C.G.S. §160D-703(b).

constituting a small percentage of the approximately 897 million acres of farmland. Agricultural land near solar and wind projects usually remained in agriculture after development.¹¹⁵

A note of census terminology is important: the USDA five-year census identifies agricultural land as “land in farms” and further classifies all agricultural use (for crops, swine and poultry, animal grazing, etc.) under that designation. This narrative generally uses the term “agricultural land” to mean “land in farms” supporting all forms of agricultural use. The USDA census further breaks down land in farms by production type, and creates the category “cropland” which is the sum of five components, including (1) cropland harvested (net of double cropping), (2) crop failure, (3) cultivated summer fallow, (4) cropland pasture, and (5) idle cropland.¹¹⁶ While analyses cited below generally refer to

¹¹⁵ Maguire, K., Tanner, S. J., Winikoff, J. B., & Williams, R. (2024). *Utility-scale solar and wind development in rural areas: Land cover change (2009–20)* (Report No. ERR-330). U.S. Department of Agriculture, Economic Research Service.

<https://www.ers.usda.gov/publications/pub-details?pubid=109208>

¹¹⁶ For an explanation of each subcategory, see U.S. Department of Agriculture, Economic Research Service (2024). *Major Land Uses—Documentation*. Retrieved November 29, 2025 from

<https://www.ers.usda.gov/data-products/major-land-uses/documentation/>.

Note: For example, “grazed land” is “land on which no crops were harvested this year but is considered to be in long-term crop rotation and/or could have been cropped without additional improvement.”

agricultural land (e.g. AFT), further analysis is devoted to converted cropland (e.g. NCSEA).

Specific to North Carolina, analyses of solar development’s impact on agricultural land has been conducted by NCSEA. In its 2025 update to its original 2017 Solar Land Use and Agriculture Study, NCSEA used geographic information system (GIS) software to quantify the amount of solar land. Using its Renewable Energy Database (REDB) of utility-scale solar (USS) installations 1 MW and greater in the state (sourced from the North Carolina Utilities Commission website), NCSEA overlaid drawn solar footprints over National Land Cover Database (NLCD) land use parcel data to calculate the amount of land that the solar footprints covered in each land use category. The analysis found that the installations occupied a total of 40,284 acres of all land categories, or 0.13% of the approximately 31.4 million acres of land in the state. NCSEA further found that USS installations are located on 34,012 acres of agricultural land (defined in the study as the cultivated crops, evergreen forest, and pasture/hay land use categories), or 0.42% of the 8.1 million acres of agricultural land in the state per the 2022 USDA census. Further, USS facilities occupy 24,633 acres, or 0.57%, of the 4,337,847 acres of land categorized as cultivated crops in NCSEA’s analysis.

Taken as a fraction of the 2022 USDA Census' 4.88 million acres of cropland, the study found that 0.50% of the state's cropland is used for USS development.¹¹⁷ A map of the solar installations in the state prepared by NCSEA is available at: <https://www.energync.org/map/solar-map/>.¹¹⁸ The study update did not include a revision to the original 2017 analysis' finding that on average, the solar projects occupied 5.78 acres per MW.¹¹⁹ However, solar projects generally range from 5 to 7 acres per MW.¹²⁰

North Carolina has seen conversion of total agricultural land to various forms of development for many years.¹²¹ Solar facilities use 0.13% of the total land

¹¹⁷ Carey, J., & Pate, D. (2025). *North Carolina Solar Land Use and Agriculture Study – 2025 Update*. North Carolina Sustainable Energy Association. Retrieved November 9, 2025, from https://www.energync.org/wp-content/uploads/2025/11/2025_Solar_Ag_NCSEA_REV.pdf

¹¹⁸ North Carolina Sustainable Energy Association. (n.d.). *North Carolina installed solar systems*. Retrieved December 2, 2025, from <https://www.energync.org/map/solar-map/>

¹¹⁹ North Carolina Sustainable Energy Association (2017). *Land Use Analysis of NC Solar Installations*. North Carolina Sustainable Energy Association. Retrieved November 9, 2025 from https://energync.org/wp-content/uploads/2017/03/Solar_Land_Use_Analysis_Results.pdf

¹²⁰ SolarLandLease. (2017, December 30). *How Much Land Does a Solar Farm Need?* SolarLandLease. <https://www.solarlandlease.com/how-much-land-does-a-solar-farm-need>

¹²¹ Cline, M. (2024, August 5). *Growing population brings challenges to farmland*. North Carolina Office of State Budget and Management. <https://www.osbm.nc.gov/blog/2024/08/05/growing-population-brings-challenges-farmland>

area of North Carolina, of which 0.42% was agricultural land according to the above NCSEA study. By comparison “Developed, Open Space” redevelopment (e.g. large lot residential, golf courses, or parks) occupies 7.18% of converted agricultural land and “Developed, Low Intensity” redevelopment (i.e. single family housing) covers 3.42% of converted agricultural land.¹²² [Note that NCSEA's definitions of “agricultural land” and “cropland” may not precisely align with USDA's definitions of “land in farms” and “cropland.” While not a direct apples-to-apples comparison, this formulaic approach provides a useful illustration of development impact.]

Since 1940, total cropland (the subset of agricultural land) in North Carolina has fallen from 8.42 million acres¹²³ to 4.88 million acres (as of the 2022 census)¹²⁴, and the North Carolina Department of Agriculture and

¹²² Carey, J., & Pate, D. (2025). *North Carolina Solar Land Use and Agriculture Study – 2025 Update*. North Carolina Sustainable Energy Association. Retrieved November 9, 2025, from https://www.energync.org/wp-content/uploads/2025/11/2025_Solar_Ag_NCSEA_REV.pdf

¹²³ U.S. Department of Agriculture, National Agricultural Statistics Service (1940). *1940 Census of Agriculture: North Carolina State Tables*, Tbl. 1 (1940), https://www.nass.usda.gov/AgCensus/archive/census_year/1940-census/index.html

¹²⁴ U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). *2022 Census of Agriculture – State Data: North Carolina* (Vol. 1, Ch. 1). https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1_Chapter_1_State_Level/North_Carolina/st37_1_001_001.pdf

Consumer Services (NCDA&CS) has identified farmland preservation as one of its top priorities since 2005.¹²⁵ Despite this decrease in acres of cropland, the market value of crops (non-animal products) produced in the state has steadily increased.¹²⁶ There is an open question regarding the impact of solar PV development on agricultural outcomes: Specifically, how does solar PV development impact agricultural outcomes (production, revenue, input costs, etc.) and how does this compare to impacts from other types of development such as residential and commercial?

An economic estimate of solar PV conversion of cropland based on the statewide census value of all crops - the total of grains and legumes, tobacco, cotton, vegetables, fruits, berries and nuts, Christmas trees, and hay totalling \$4,735,103,587.50 (30.25% of \$15,653,235,000 total agricultural output)¹²⁷ - is certainly a challenge

without knowing which specific crops are displaced, and what costs are avoided by the producers of those particular crops. Consider a simplified scenario focusing all solar development on a single double crop situation - summer soybean and winter wheat - using reported acreage and bushel (bu) production displaced by solar development (accepting NCSEA's current figure of USS on 0.57% of cropland), and assume that *only* soybean/wheat acreage is developed.

¹²⁵ North Carolina Department of Agriculture & Consumer Services. (n.d.). *ADFP trust fund history and archives*.
<https://www.ncagr.gov/divisions/farmland-preservation/history>

¹²⁶ U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). *2022 Census of Agriculture – State Data: North Carolina* (Vol. 1, Ch. 1).
https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1_Chapter_1_State_Level/North_Carolina/st37_1_001_001.pdf

¹²⁷ U.S. Department of Agriculture, National Agricultural Statistics Service. (2024). *North Carolina agricultural statistics 2023 highlights* (p. 1).
https://www.nass.usda.gov/Statistics_by_State/

[North_Carolina/Publications/Annual_Statistical_Bulletin/AgStat/NCHighlights.pdf](https://www.ncagr.gov/Publications/Annual_Statistical_Bulletin/AgStat/NCHighlights.pdf)

That analysis using 2022 crop (bushel) figures and 2025 prices might look like this:^{128,129}

Crop	Acres (2022)	Bu Total	0.57% Bu Displaced	Price/Bu (Dec 2025)	Crop Value (Bu Displaced)
Soybean	1,707,530	66,254,440	377,650	\$11.40	-\$4,305,214
Wheat	430,720	26,461,481	150,830	\$5.30	-\$799,399
Total Double Crop					-\$5,104,613

(Note: NASS data also includes total farm expenses, which are not tied to the soybean and wheat production for this example, and therefore not included)

¹²⁸ Business Insider. (n.d.) *Soybeans Price*. Retrieved December 1, 2025 from <https://markets.businessinsider.com/commodities/soybeans-price>

¹²⁹ Agriculture.com. (n.d.) *Markets: Commodity Prices*. Retrieved December 1, 2025 from <https://www.agriculture.com/markets/commodity-prices>



Accepting that the above displacement calculation is illustrated on the false premise that total soybean and wheat production reported is the result of double-cropping the same acreage, and that cropland conversion only impacts these two crops (on the same acre), this is only a suggested starting point for assessing crop value displaced by the change in use from cropland production to solar PV use (i.e. addressing only “cost” side of any future cost-benefit analysis). This descriptive and static example does not take into account changes in productivity per acre and production shifts as a result of solar PV development or any long-run changes. An accurate crop displacement value would require in-depth review of actual crop rotations displaced by solar development on a county/regional or site-by-site basis (similar to the geo-spatial analysis methods deployed by AFT and NCSEA); perhaps this is a broad framework for future research. Further research would need to analyze displaced production’s economic and social impact on production support sector (e.g. seed, chemicals, equipment, labor) and downstream distribution and processing, including grain elevators, transportation, cotton gin, and vegetable distribution. As noted earlier in this white paper, the impact to individual operations not sharing in solar PV lease income is acknowledged as a more immediate concern.

Some communities may rightfully ask about the extent of future solar PV development in their area. Below are various analytical looks at the impact of the unrealistic extreme down to the current growth projection by Duke Energy currently before the NCUC.

What If Solar Panels Produced All Electricity *This Year*? If utility-scale solar produced 100% of North Carolina’s current annual electricity consumption, solar PV facilities - at 7 acres of land per MW - would occupy about 523,438.23 acres of land, or 6.46% farmland, or 10.7% of cropland. The calculation would begin as outlined below:

$$\text{Total Annual Hours} \times \text{Panel Capacity Factor} = \text{Effective (Solar) Hours}$$

According to the Electronic Industries Association (EIA), North Carolina consumed 136,904,526 megawatt hours (MWh) in 2024, and there are 8,760 hours in a year (24 hours x 365 days). Because solar panels cannot produce electricity every hour of the week, a capacity factor of 0.209 (approximately 20.9%) is considered the average percentage of the maximum capacity the panels actually produce throughout the year, accounting for night, clouds, and panel angle. Thus:

$$8,760 \times 0.209 = 1,830.84$$

To determine how much solar MW capacity is required to meet the annual required capacity:

$$\text{Required Capacity (MW)} = \frac{\text{Total Annual Retail Sales (MWh)}}{\text{Effective Annual Operating Hours}}$$

The following calculations refer to NCSEA’s 2025 Solar Land Use and Agriculture Study, where land areas are found to be 31.4 million acres for total state land, 8.1 million acres for state agricultural land (made up of cultivated cropland, evergreen forest, and pasture/hay land uses), and the USDA National Agricultural Statistics Service 2022 Census, where state cropland is found to be 4.88 million acres (again acknowledging NCSEA and USDA definitions for such land may differ). So then: $136,904,526 / 1830.84 = 74,776.89$ MW capacity from solar panels. At 7 acres per MW, this equals 523,438.23 acres. Out of North Carolina total land of 31.4 million acres, that is 1.67%, about the size of Wake County. If this large footprint were placed on agricultural land, it would occupy 6.46% of those 8.1 million acres; if cropland only, then 10.73% of those 4.88 million acres.

This unrealistic extreme only illustrates the limited possible magnitude of land usage for solar even at the highest theoretical generation levels, and would be less than the amount of agricultural land occupied by “Developed, Open

Space” (6.46% < 7.18%) using NCSEA’s definition and calculation. And in that fantastical 100% “solar future,” ground-mounted utility-scale solar would not be the only source of solar electricity as other photovoltaic sources grow, as more rooftop and parking lot canopies are deployed, reducing the need for green field development. A DOE study found that rooftop systems have the technical capability to meet 23.5% of North Carolina’s electricity demand.¹³⁰ To further abuse the above formulas, that would take utility-scale down to 100% - 23.5% = 76.5%, times 523,438.23 acres = 400,430.25 acres, or 4.94% of agricultural land or 8.21% of all crop land.

Optimal Renewables Source Analysis.

A Stanford University study of the optimal mix of renewable energy sources for each state to achieve 100% renewable energy found that North Carolina would get only 26.5% of its electricity from utility-scale solar plants.¹³¹ Even at this still highly expanded level of solar development, based on the 6.46% agriculture land use for 100% solar figure calculated earlier,

¹³⁰ Gagnon, P., Margolis, R., Melius, J., Phillips, C., & Elmore, R. (2016, January). *Rooftop solar photovoltaic technical potential in the United States: A detailed assessment*. National Renewable Energy Laboratory. <http://www.nrel.gov/docs/fy16osti/65298.pdf>

¹³¹ Mark Z. Jacobson (2016). *Repowering 100% of all Energy in the United States and the World for 100% of the People at Low Cost With Clean and Renewable Wind, Water, and Sunlight (WWS)*. Stanford University. <http://web.stanford.edu/group/efmh/jacobson/Articles/I/16-10-31-SummaryRoadmaps.pdf>

the amount of North Carolina agricultural land use for this percentage of solar would be around 1.71%. For cropland only, this would be around 2.84%.¹³²

The New CEPS Mandate. Closer to reality, the solar PV current and future installations necessary to meet the new 12.5% Clean Energy and Energy Efficiency Portfolio Standard (CEPS) requirement¹³³ - about 9.35 GW of solar PV capacity - would require about 65,450 acres of land which would amount to 0.8078% of agricultural land in the state (9.35 GW = 9,350 MW; 9,350 MW x 7 acres = 65,450 acres; 65,450 acres/8.1 million acres of agricultural land = 0.81%).¹³⁴ The same formula applied to NC’s 4.88 million acres of cropland would amount to 1.34% (65,450 acres/4.88 million acres of agricultural land = 1.34%). This is not an insignificant amount of land, but it is

¹³² For agricultural land: 6.46% * 0.265 = 1.71%. For cropland: 10.7% * 0.265 = 2.8355%.

¹³³ Session Law 2023-138 (Senate Bill 678). <https://www.ncleg.gov/EnactedLegislation/SessionLaws/PDF/2023-2024/SL2023-138.pdf> Note: CEPS is the 2023 update to the 2007 Renewable Energy Portfolio Standards (REPS) statutory mandate.

¹³⁴ Using total electric retail sales for North Carolina from EIA 2024 data and EIA North Carolina photovoltaic capacity factor of 20.9. Total retail sales of 136,904,526 * 12.5% = 17,113,065.8. To find the necessary MW: 17,113,065.8/(8760 hours in a year * 209 capacity factor) → 17,113,065./1,830.84 = 9,347.11 MW. 9,347.11 MW * 7 acres per MW = 65,429.78 acres. 65,429.78 acres/8.1 million total acres of agricultural land in the state derived from NCSEA 2025 study = 0.8078% of agricultural land taken by solar.

less than the percentage taken by other land uses cited above.

House Bill 951 Carbon Reduction Goals Model.

An additional, more realistic scenario is considering the solar capacity necessary to meet North Carolina's power sector carbon neutrality goals. House Bill 951 (2021)¹³⁵ established goals for Duke Energy to meet a 70% carbon emission reduction goal by 2030 and reach carbon neutrality by 2050. Senate Bill 266 (2025)¹³⁶ has since removed the 70% by 2030 interim target, but a study from the Duke Nicholas Institute that considers different policy paths for meeting the original goals still provides a helpful reference point for potential land use impacts. Modeling in the study resulted in anywhere from 10.9 to 35.3 GW of *new* solar generation capacity by 2050.¹³⁷ Assuming the most aggressive case for capacity addition, the necessary land for new solar would be 247,100 acres (35.3 GW/1 MW = 35,300 MW; 35,300 MW x 7 acres = 247,100 acres). This would take up 3.05% of the state's current agricultural acreage (247,100 acres/8.1 million acres),

¹³⁵ Energy Solutions for North Carolina Act (S.L. 2021-165).

¹³⁶ The Power Bill Reduction Act (S.L. 2025-78).

¹³⁷ Konschnik, K., Ross, M., Monast, J., Weiss, J., & Wilson, G. (2021). *Power Sector Carbon Reduction: An Evaluation of Policies for North Carolina*. Nicholas Institute for Environmental Policy Solutions.

https://nicholasinstitute.duke.edu/sites/default/files/publications/Power-Sector-Carbon-Reduction-An-Evaluation-of-Policies-for-North-Carolina-Revised_0.pdf

slightly less than agricultural land conversion to Developed, Low Intensity (3.05% < 3.42%) and only roughly half of the land use conversion to Developed, Open Space (3.05% < 7.18%). Again, applied to *cropland* only, this would take up 5.06% of the state's current cropland (247,100 acres/4.88 million acres = 5.06%).

Duke Energy's Current Resource Plan.

A final, and perhaps most realistic, estimate of forthcoming solar land use may be taken from Duke Energy's own Carbon Plan and Resources Plan, which was updated to reflect Senate Bill 266. Duke's plan outlines procuring 8,175 MW of solar by 2040, which would require 57,225 acres (8,175 MW of solar * 7 acres per MW = 57,225 acres), which would only take up 0.7065% of the state's current agricultural acreage (57,225/8.1 million acres = 0.7065%).¹³⁸ Applied to *cropland* only, this would take up 1.17% (57,225/4.88 million acres = 1.17%).

South Carolina's Current Resource Plans.

Looking to South Carolina, similar trends of solar impacts on agricultural land can be seen in a study prepared by a University of South Carolina research economist for a

¹³⁸ Duke Energy Carolinas. (2025). Carolinas Resource Plan Chapter 3: Portfolio Development and Evaluation. In *duke-energy.com*.

<https://www.duke-energy.com/-/media/pdfs/our-company/carolinas-resource-plan/2025/03-chapter-3-portfolio-dev-and-eval-web.pdf?rev=c4ca537b9cfa45ce9254299f87d7dda2>

group of renewable energy developers. The study analyzes the Integrated Resource Plans filed by South Carolina's three primary utilities as of 2024. Taken together, the plans project that solar production will increase from approximately 2,427 MW in 2024 to 11,047 MW by 2035. Assuming that 1 MW of solar takes 8 acres (based on an estimate from the South Carolina Department of Agriculture), the build out of solar capacity would take up a maximum of 1.4% of all 4.8 million acres of agricultural land in South Carolina. Additionally, future non-solar development (delineated as urban, commercial, and residential construction) would likely displace agricultural land at greater than six times the rate of future solar development in the state.¹³⁹

Lastly, regarding solar development's fractional percentage of total Carolinas land compared to other land uses, it is worth noting that solar energy's land use requirements are comparable to those of existing energy sources. According to a Massachusetts Institute of Technology (MIT) study, supplying 100% of United States electricity demand in 2050 with solar would require use of about 0.4% of the country's land area; this is less than the

¹³⁹ Von Nessen, J. (2024). *The Economic Impact of the Solar Industry in South Carolina*. Carolinas Clean Energy Business Association. <https://carolinasceba.com/wp-content/uploads/2024/12/The-Economic-Impact-of-the-Solar-Industry-in-South-Carolina-November-2024.pdf>

land area occupied by major roads, and about the same amount of land that has been disturbed by surface coal mining at the time of the study's publication.¹⁴⁰

2.2.3 Addressing Local Concern, Part II: Available Research on the Impact of Solar PV Development on Surrounding Property Values

The expansion of utility-scale solar development has prompted growing interest among researchers and policymakers regarding its effects on property and land values. A number of studies by researchers in academia as well as a report of private sector appraisal experience have examined the impact of solar development on residential and farmland values. The results of the studies suggest a complex pattern in which solar development has been shown to both depress and enhance property values in different contexts across the U.S.

For example, Abashidze and Taylor examine the relationship between solar farms and agricultural land values in North Carolina by analyzing sales transactions for parcels adjacent to or near ground-mounted solar facilities. The authors find no consistent direct

¹⁴⁰ MIT Energy Initiative (2015). *The Future of Solar Energy*. <https://energy.mit.edu/wp-content/uploads/2015/05/MITEI-The-Future-of-Solar-Energy.pdf>

positive or negative effects of solar farms on nearby agricultural land values. However, they find that agricultural land located near transmission infrastructure appreciated in value once a nearby solar project was constructed. This suggests that solar farms may signal the suitability of land for future solar use, enhancing its attractiveness for development or leasing. This nuanced result highlights that value effects depend not only on the presence of solar infrastructure but also on related site-specific factors such as transmission access.¹⁴¹

Hua et al. conducted a national study investigating how large-scale solar installations affect property values across the United States. Leveraging data on nearly 3,700 solar projects and millions of real estate transactions distinguishing between agricultural or vacant lands and residential properties, the authors find that agricultural or vacant lands located within 2 miles of large solar projects experience significant increases in value—about 19.4% on average—attributed to heightened developer interest and the potential for future solar leasing. Conversely, residential properties within 3 miles of such projects experience value declines averaging 4.8%, reflecting a combination of perceived disamenities, such as changes to rural

¹⁴¹ Abashidze, N., & Taylor, L. O. (2023). Utility-scale solar farms and agricultural land values. *Land Economics*, 99(3), 327–342. <https://doi.org/10.3368/le.99.3.102920-0165R>

landscapes and visual impacts, as well as possible concerns about noise or infrastructure changes. This study underscores that the economic impacts of solar projects vary by distance to solar installations and property type.¹⁴²

Policy at different levels can also influence the effects of solar developments on property values. Li, Zhang, and Ortiz-Bobea, analyze farmland transactions in New York State between 2007 and 2021 focusing on the impacts of the 2015 Shared Renewable Program (SRP), a legislative initiative designed to facilitate the development of large-scale solar projects. They found that farmland parcels within 2 miles of substations identified as suitable for solar development sold for 15–18% more after SRP implementation than comparable parcels farther away. These results suggest that solar-enabling legislation can substantially increase farmland values, primarily by improving the perceived economic potential of land for renewable energy use.¹⁴³

¹⁴² Hua, C., Chen, Z., Liu, P., Zhang, W., He, X., & Bosch, D. (2025). Impact of large-scale solar on property values in the United States: Diverse effects and causal mechanisms. *Proceedings of the National Academy of Sciences*, 122(24), e2418414122. <https://doi.org/10.1073/pnas.2418414122>

¹⁴³ Li, Z., Zhang, W., & Ortiz-Bobea, A. (2024). Impacts of large-scale solar-enabling legislation on farmland values. Cornell SC Johnson College of Business Research Paper. <https://doi.org/10.2139/ssrn.4942012>

Appraisal-focused reports provide another perspective into how solar developments are perceived in real estate markets. Kirkland Appraisals, LLC conducted a study in North Carolina, reviewing university studies and consulting with county assessors and local real estate professionals. Their findings indicated that solar farms had no measurable impact on property values, with the consensus being that solar farms did not negatively affect property values in their areas.¹⁴⁴ The American Clean Power Association reviewed various research studies and found that utility-scale solar installations had not had a negative impact on local property values. Their research included reviewing published studies prepared by academia, as well as other appraisers, and conducting interviews with county assessors and local real estate professionals, who had experience with properties transacting near existing solar facilities.¹⁴⁵ In contrast, a study of New England solar facilities by the University of Rhode Island found that suburban residential property values suffered negative impacts when nearby solar farms replaced resources perceived as scarce, such as green space. However, the same study found no associated

¹⁴⁴ Kirkland Appraisals, LLC. (2025). Property value impact study: Bluegrass Creek Solar. <https://dev.evansvilleapc.com/assets/docs/Bluegrass%20Creek%20Solar/1%20-%20Property%20Value%20Impact%20Analysis.pdf>

¹⁴⁵ American Clean Power Association. (2022). Property values and utility-scale solar facilities. <https://cleanpower.org/resources/property-value-s-and-utility-scale-solar-facilities/>

impact on property values for solar farms located in rural areas, suggesting that the context and location of solar installations play a significant role in determining their impact on property values.¹⁴⁶

These studies contribute to a nuanced understanding of how solar developments affect property and land values. Careful consideration of siting, zoning, and regulatory incentives is critical to maximizing the economic benefits of solar projects while mitigating adverse impacts on surrounding communities.

3. Solar Development Impacts on Farmland and Farmland Restoration

This subsection provides an overview of impacts that solar development may have on the local environment and future agricultural productivity of parcel soils. First, the discussion of soil impacts is divided into the following subtopics: soil quality and compaction; erosion and vegetation management; toxicity and material leaching; pollinators and biodiversity; and

¹⁴⁶ University of Rhode Island. (2021). Solar's impact on rural property values. *American Society of Farm Managers and Rural Appraisers*. <https://www.asfmra.org/blogs/asfmra-press/2021/02/16/solars-impact-on-land-values>

temperature effects. Below are illustrations of practices designed to manage impact on the future agricultural productivity of the land hosting a solar PV facility. Second, the discussion of decommissioning solar projects covers the typical process of decommissioning, relevant regulations in the Carolinas including required processes and financial assurance, and decommissioning cost and salvage value estimates.

3.1 Impact on Soil Health

3.1.1 Construction Grading and Compaction

Utility-scale solar installations can alter soil structure and function through grading, trenching, and repeated vehicular traffic during construction and maintenance. The amount of grading necessary to prepare a parcel for a utility-scale solar facility is dependent on the slope of land and the type of solar mounting used. In much of North Carolina, fixed-tilt mounting of solar PV requires little to no grading for installation of the solar PV system. Single-axis tracking systems that slowly rotate each row of panels to track the sun's path across the sky generally require flatter land (typically less than 8% grading) and thus more often require grading of the site, particularly for projects in the Piedmont region or

farther west.¹⁴⁷ The improvements in terrain-following tracking system technology, offered by the predominant tracking manufacturers in the industry, reduce grading and soil movement during construction.^{148, 149} Historical construction practices required that topsoil be stripped and stockpiled prior to cut/fill operations. The stockpiled topsoil would then be redistributed across graded areas, to assist in growing adequate ground cover as quickly as possible to provide ground stabilization. The stripping, stockpiling and redistribution of topsoil in this manner will have some impact on the amount of organics and nutrients that remain in the soil immediately after placement. There are ecological and financial incentives for preserving topsoil at all costs and minimizing grading, as it can become costly to move and repair soil after significant grading.¹⁵⁰ Research on traditional construction and grading practices

¹⁴⁷ B. Niemann (Strata Solar), personal communication, June 20, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁴⁸ M. Delafield (Delafield Energy), personal communication, November 10, 2025).

¹⁴⁹ Jacobo, J. T. (2024, December 11). How terrain-following trackers are helping boost PV project viability. *PV Tech*. <https://www.pv-tech.org/terrain-following-trackers-helping-boost-pv-project-viability/>

¹⁵⁰ M. Delafield (Delafield Energy), personal communication, November 10, 2025).

shows that these activities can cause short-term reductions in soil porosity, infiltration capacity, and microbial activity, largely due to compaction resulting from grading operations and the use of heavy machinery.^{151, 152} Soil compaction can further limit root penetration, gas exchange, and water infiltration, increasing surface runoff and erosion potential, especially in disturbed areas near access roads or inverter pads.¹⁵³ Advances in terrain-following tracking solutions for solar PV installation has eased the need for grading, reducing the costs to developers of removing and redistributing topsoil and also reducing ecological damages from soil compaction and erosion.

While some level of compaction is unavoidable during construction, adopting soil conservation practices - such as minimizing grading, using

low-pressure machinery, and preserving native topsoil - can mitigate long-term damage. Retaining and reusing native topsoil helps preserve organic matter and microbial communities, which support vegetation regrowth and stabilize soils against erosion.^{154, 155} Proper ground stabilization practices include soil testing to determine the appropriate levels of lime, fertilizer and seed to be applied to establish ground cover. Proper installation practices require these additives to be tilled into the soil, which effectively reduces the compaction of the upper soil stratum, typically to a depth of 8"-12." Typical solar projects will not remove any topsoil from the project site, partly due to financial implications, but more importantly due to its value



¹⁵¹ Hernandez, R. R., Easter, S. B., Murphy-Mariscal, M. L., Maestre, F. T., Tavassoli, M., Allen, E. B., Barrows, C. W., Belnap, J., Ochoa-Hueso, R., Thornton, P. E., & Macknick, J. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29, 766–779. <https://doi.org/10.1016/j.rser.2013.08.041>.

¹⁵² Rabaia, M., Abdelkareem, M., Sayed, E., Elsaid, K., Chae, K., Wilberforce, T., Olabi, A.G. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*, 754, 141989. <https://doi.org/10.1016/j.scitotenv.2020.141989>.

¹⁵³ Barron-Gafford, G., Minor, R., Allen, N., Cronin, N., Brooks, A., & Pavao-Zuckerman, M. (2016). The Photovoltaic Heat Island Effect: Larger Solar Power Plants Increase Local Temperatures. *Scientific Reports* 6, Article Number 35070. <https://doi.org/10.1038/srep35070>.

¹⁵⁴ Hernandez, R. R., Easter, S. B., Murphy-Mariscal, M. L., Maestre, F. T., Tavassoli, M., Allen, E. B., Barrows, C. W., Belnap, J., Ochoa-Hueso, R., Thornton, P. E., & Macknick, J. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29, 766–779. <https://doi.org/10.1016/j.rser.2013.08.041>.

¹⁵⁵ Rabaia, M., Abdelkareem, M., Sayed, E., Elsaid, K., Chae, K., Wilberforce, T., Olabi, A.G. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*, 754, 141989. <https://doi.org/10.1016/j.scitotenv.2020.141989>.

in establishing ground cover as quickly as possible (removing soil also requires a mining permit).^{156, 157} Studies of solar sites have emphasized that retaining and re-using native topsoil helps preserve microbial communities and organic matter, which supports vegetation growth and stabilizes soils against erosion once operations begin.^{158, 159} Some landowners may steer solar projects to their least productive soils on a given piece of property to the extent practical which further minimizes the long-term

¹⁵⁶ B. Niemann (Strata Solar), personal communication, June 20, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁵⁷ M. Carroll (North Carolina Cooperative Extension), personal communication, June 20, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁵⁸ Hernandez, R. R., Easter, S. B., Murphy-Mariscal, M. L., Maestre, F. T., Tavassoli, M., Allen, E. B., Barrows, C. W., Belnap, J., Ochoa-Hueso, R., Thornton, P. E., & Macknick, J. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29, 766–779. <https://doi.org/10.1016/j.rser.2013.08.041>.

¹⁵⁹ Rabaia, M., Abdelkareem, M., Sayed, E., Elsaid, K., Chae, K., Wilberforce, T., Olabi, A.G. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*, 754, 141989. <https://doi.org/10.1016/j.scitotenv.2020.141989>.

impacts of grading and compaction on agricultural productivity.¹⁶⁰ To further prevent damage to soil due to compaction, landowners may also negotiate for practices that will result in the least amount of compaction and for roads to be constructed on less productive land.

3.1.2 Changes in Soil Composition During Lease Term

Modern agriculture relies on regular application of lime and fertilizer to maintain soil pH and fertility.¹⁶¹ Solar facilities must maintain vegetative ground cover to prevent erosion, which may help build soil quality over time; this may require periodic applications of lime and fertilizer. The gradual accumulation of organic matter from mowing and plant litter decomposition can, over years of operation, enhance soil organic carbon and restore portions of the fertility lost during site grading. A facility operation and

¹⁶⁰ B. Niemann (Strata Solar), personal communication, June 20, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁶¹ Heckman, J. (2018). *Soil Acidity and Liming: Basic Information for Farmers and Gardeners*. N.C. State Extension. Retrieved November 29, 2025 from <https://content.ces.ncsu.edu/soil-acidity-and-liming-basic-information-for-farmers-and-gardeners>.

maintenance schedule is a likely requirement to meet local permitting approval and local sedimentation ordinances, which would include a plan for maintenance of sufficient plant ground cover to protect soil from erosion. Maintaining healthy plant cover will require monitoring of soil fertility and may call for the addition of fertilizer or lime to ensure sufficient nutrients are available for plant growth and that soil pH is adequate. Vegetation mixes may help balance soil nutrient needs, but will need to be managed. Species composition will change over time.¹⁶² NRL and others are researching and using vegetation mixes that include many native grasses with deep root systems; many include some nitrogen fixing plants as well. Maintaining healthy ground cover, especially varieties with deep root systems, can serve to keep the soil arable for potential future agricultural use.

¹⁶² J. Hudyncia (North Carolina Department of Agriculture and Consumer Services), personal communication, July 8, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

Highlighting the need for comprehensive soil fertility maintenance, a study (published in January 2025) summarizing the 2021 investigation of 32 solar facilities in England and Wales (United Kingdom, UK) found that soil compaction was 14.4% and 15.5% higher underneath panels than in gaps and undeveloped pasture, respectively. Researchers also determined that particulate organic matter was 29.1% and 23.6% lower under panels than in gaps and pasture. On the other hand, the study did find that mineral nitrogen was 30.5% higher under panels, with phosphorus levels 60% higher within the facility than outside pastures.¹⁶³ These findings support the broader evidence that, with appropriate soil management and minimal compaction, long-term impacts on soil quality at solar facilities can be low and sometimes neutral or positive. After a solar project is removed, a routine soil test (available from NCDA&CS)¹⁶⁴ should be obtained to determine fertility requirements, including lime, for optimum crop production.

¹⁶³ Carvalho, F., Montag, H., Bentley, L., Šarlej, R., Broyd, R., Blaydes, H., Cattin, M., Burke, M., Wallwork, A., Ramanayaka, S., White, P., Sharp, S., Clarkson, T., & Armstrong, A. (2025). Plant and soil responses to ground-mounted solar panels in temperate agricultural systems. *Environmental Research Letters*, 20(2), 024003. <https://doi.org/10.1088/1748-9326/ada45b>

¹⁶⁴ More information available at <https://www.ncagr.gov/Divisions/Agronomic-Services/soil-testing>. Soil sample boxes for mailing to NCDA&CS soil labs are available in county NC Cooperative Extension offices across North Carolina.

3.1.3 Erosion and Vegetation Management

Erosion risk is closely linked to site preparation and vegetation management strategies. Increased soil erosion is one of the most consistent adverse effects of utility-scale solar, particularly in desert and grassland environments, where removal of vegetation exposes bare soil to wind and water erosion.¹⁶⁵ The construction of access roads and panel rows can concentrate runoff, leading to increased sediment transport. One solar panel runoff study indicated that solar panels over a grassy field do not change runoff volume, peak discharge (e.g., the maximum rate of runoff), or time to peak (a measurement of water travel time), demonstrating the importance of vegetation and stormwater control measures. Further, the study generally found that structural stormwater management would not be necessary to prevent adverse impacts.¹⁶⁶

¹⁶⁵ Hernandez, R. R., Easter, S. B., Murphy-Mariscal, M. L., Maestre, F. T., Tavassoli, M., Allen, E. B., Barrows, C. W., Belnap, J., Ochoa-Hueso, R., Thornton, P. E., & Macknick, J. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29, 766–779. <https://doi.org/10.1016/j.rser.2013.08.041>.

¹⁶⁶ Rouhangiz, Y., Zaliwciw, D., Cibir, R., & McPhillips, L. (2022). Minimizing environmental impacts of solar farms: a review of current science on landscape hydrology and guidance on stormwater management. *Environmental Research: Infrastructure and Sustainability*, 2(3). <https://doi.org/10.1088/2634-4505/ac76dd>

However, stormwater runoff's impact is still an ongoing area of research. A Virginia Tech study provides preliminary evidence that utility-scale solar development can increase stormwater runoff relative to pre-existing land uses such as agriculture and forest cover. Based on monitoring at three solar facilities in Virginia, the researchers found that catchments within solar arrays often generated rapid and sometimes substantial surface runoff during storm events, with runoff volumes generally exceeding those from nearby reference areas. Estimated runoff parameters (curve numbers) at solar sites were frequently high and variable; often comparable to or greater than those for row-crop agriculture and substantially higher than forested or mixed vegetation areas. Time of concentration (the speed at which runoff responds to rainfall) at solar sites was similar to agricultural land but faster than forested areas. As an early stage of a six-year project, the report emphasizes that additional data—especially on water quality, soil properties, and long-term site changes—are needed to better understand environmental impacts and inform improved stormwater management practices at utility-scale solar facilities. Generally, the results imply that solar development is increasing stormwater runoff volumes relative to pre-development conditions across a range of sites and storm events and suggests uncertainty about whether current stormwater design

assumptions for solar installations are appropriate. As the study progresses, more comprehensive data on site soil, water quantity, and water quality impacts will be available to inform stormwater management.¹⁶⁷

In Virginia, the DEQ had previously only considered solar panel support posts and beams to be impervious under Virginia Stormwater Management Program requirements. However, a 2022 change in regulation has modified solar panels to be considered impervious when performing water quantity and quality regulations, indicating a range of approaches in the Southeast.¹⁶⁸ As the above study progresses, it will examine additional sites constructed under the new regulation.¹⁶⁹

According to its current Stormwater Design Manual, the North Carolina Department of Environmental Quality (NCDEQ) allows solar panels associated with ground-mounted solar farms to be considered pervious if configured such that they promote

sheet flow of stormwater from the panels and allow natural infiltration of stormwater into the ground beneath the panels.¹⁷⁰ For solar development, an erosion control and sedimentation permit is required, which involves on-site inspections and approval by the NCDEQ. The permit requires establishment of permanent vegetative ground cover sufficient to restrain erosion; according to NCDEQ staff, the site must be “completely stabilized,” although this does not require a specific percentage of ground cover.¹⁷¹ In-depth information on erosion control and sedimentation laws, rules, principles, and practices is available on the NCDEQ’s website and solar PV stormwater management best practices manuals.^{172, 173}

¹⁶⁷ Stewart, R., Mier-Valderrama, L., Hoben, J., Sample, D., & Daniels, W. L. (2025). Preliminary Report on Runoff Characteristics from Utility-Scale Solar Sites. In https://www.deq.virginia.gov/home/showpublisheddocument/32469?utm_medium=email&utm_source=govdelivery. Virginia Tech College of Agriculture and Life Sciences.

¹⁶⁸ Rolband, M. (2022). *Post-Development Stormwater Management at Solar Projects* [Memo]. VA DEQ. <https://www.deq.virginia.gov/home/showpublisheddocument/13985/637842474433400000>

¹⁶⁹ *Id.*

¹⁷⁰ N.C. Department of Environmental Quality (2018). *2018 E-6 Solar Farm Manual*. <https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/2018-e-6-solar-farm-manual/download>.

¹⁷¹ J. Ventaloro (North Carolina Department of Environmental Quality), personal communication, June 14, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁷² NC DEQ. (n.d.). Erosion and Sediment Control Planning and Design Manual | NC DEQ. <https://www.deq.nc.gov/about/divisions/energy-mineral-and-land-resources/erosion-and-sediment-control/erosion-and-sediment-control-planning-and-design-manual>

¹⁷³ Dunder, W. (2023, February 15). Federally Funded Study Outlines Best Practices for Managing Solar Farm Stormwater Runoff. *Great Plains Institute*. <https://betterenergy.org/blog/federally-funded-stu>

Site decisions such as racking, grading, and soil disturbance are not necessarily dictated by stormwater regulation. However, developers may choose to minimize site disturbance and promote shallow vegetation to reduce the need for additional stormwater compliance measures.¹⁷⁴ Once permanent vegetation is established, it is necessary to maintain soil pH and fertility as mentioned above in order to ensure sufficient, healthy, and continuous ground cover for erosion control.

Regardless of required vegetation regimes for erosion control, it should be noted that solar PV site developers and owners are strongly incentivized to limit sedimentation transfer to adjoining parcels that may raise common law nuisance, trespass, and negligence claims. Given that vegetation maintenance is common practice, failure resulting in damage to neighboring properties would fall below a standard of reasonableness.¹⁷⁵ Likewise, sedimentation of nearby waterways may give rise to federal and state environmental agency intervention (e.g. release of 'dredge and fill' material to jurisdictional waters).

[dy-outlines-best-practices-for-managing-solar-farm-stormwater-runoff/](#)

¹⁷⁴ M. Delafield (Delafield Energy), personal communication, November 10, 2025.

¹⁷⁵ Associated Press. (2025, January 10). Silicon Ranch settles with Georgia couple in muddy runoff case. *The Atlanta Journal-Constitution*. <https://www.ajc.com/news/business/silicon-ranch-settles-with-georgia-couple-in-muddy-runoff-case/VFW4S4KO3ZF6VB6PGROV2YCERU/>

Maintenance of vegetation on site can be accomplished using several options, including but not limited to the following: mowing, weed eaters, herbicides, and sheep. Reductions in fertilizer use on the site will slow growth of vegetation and weeds. Mowing allows the solar PV facility manager to have the option of laying cut grass or vegetation on the grounds of the site to decompose and improve long-term soil fertility. In some cases, facility managers allow grazing animals, normally sheep, to graze the solar site grounds and control the vegetation and weeds, which also returns organic matter to the soil on site. (see note on Dual Use, Section 2.1.5).

Intensive herbicide use may cause chemical leaching, which can reduce soil biodiversity and in extreme cases contaminate groundwater.¹⁷⁶ Herbicide use at solar facilities is typically similar to that in agriculture, and the types of herbicides used are similar between the two uses. As such, the impact of herbicides used at solar facilities on neighboring land and the environment is likely to be no more than that of conventional agriculture. Herbicide use differs widely among different crops and farming techniques, so the change in herbicide appliance between

¹⁷⁶ Rabaia, M., Abdelkareem, M., Sayed, E., Elsaid, K., Chae, K., Wilberforce, T., Olabi, A.G. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*, 754, 141989. <https://doi.org/10.1016/j.scitotenv.2020.141989>.

agricultural and solar use will vary in individual cases, but in the aggregate, there is no reason to believe that solar facilities will result in more herbicide impacts on neighboring lands than do current agricultural uses.¹⁷⁷ Herbicide use can be discontinued one to two years before decommissioning of a site, minimizing any residual impact on crop production at former solar sites.¹⁷⁸

Alternatively, integrated vegetation management including selective mowing, native plant reseeding, or the introduction of grazing animals has been shown to stabilize soils and promote biodiversity. A number of sites use sheep at low densities to maintain vegetation during the growing season, although the sheep do not fully replace the need for mowing and/or herbicide use. The sheep are managed by local sheep farmers accessing the facility through agreement, and the demand for sheep at solar facilities has been beneficial for North Carolina's sheep

industry.¹⁷⁹ The grazing of sheep at solar facilities incorporates local farmers into the management of the sites, engaging the local community with solar development. The growth of solar farms may represent an opportunity for the North Carolina sheep industry, with thousands of acres that are fenced well for sheep, and allow North Carolina farmers to diversify into new agricultural products for which there is increasing demand.¹⁸⁰

The expansion of solar installations into rural and semi-natural landscapes has prompted growing attention to impacts on pollinators and other beneficial insects. The shading from panel arrays and changes in vegetation composition can also alter floral resources and nesting habitats. A 2022 research report suggests that managed vegetation beneath and around panels can provide valuable habitat for pollinators, particularly when seeded with native wildflowers or low-growing forbs

¹⁷⁷ North Carolina Clean Energy Technology Center (2017). *Health and Safety Impacts of Solar Photovoltaics*. https://nccleantech.ncsu.edu/wp-content/uploads/Health-and-Safety-Impacts-of-Solar-Photovoltaics-2017_white-paper.pdf

¹⁷⁸ R. Nielsen (First Solar), personal communication, June 23, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.

¹⁷⁹ Chelsea Kellner. *Got Sheep? Want a Solar Farm?* North Carolina State University College of Agricultural and Life Sciences News. September 2016. Retrieved November 2025 from <https://cals.ncsu.edu/news/got-sheep-want-a-solar-farm/>.

¹⁸⁰ B. Phillips (Sun-Raised Farms), personal communication, June 21, 2017, as cited in NC Clean Energy Technology Center. (2019). *Balancing agricultural productivity with ground-based solar photovoltaic (PV) development*. N.C. State University. <https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf>.)

(non-woody flowering plants).¹⁸¹ The concept of a “solar-pollinator habitat” is emerging as a dual-benefit strategy to maintain energy production while enhancing biodiversity. These approaches not only support ecosystem services but can also improve site aesthetics and sedimentation management, and perhaps community acceptance. Thus, pollinator-friendly management is increasingly viewed as a best practice for reducing the ecological footprint of utility-scale solar farms.

3.1.4 Soil Contamination Concerns: Material Leaching and Concepts of Toxicity

There is common concern that the years-long presence of solar panels on a parcel will contaminate its soil, perhaps render it “toxic,” and such views are often expressed at public input sessions and hearings.¹⁸² Such questions are logical, given that years of agricultural use - based on bio-based photosynthesis - will give way to an engineered process of photo-electric generation, using non-plant-based

¹⁸¹ Walston, L., Barley, T., Bhandari, I., Campbell, B., McCall, J., Hartmann, H., Dolezal, A. (2022). Opportunities for agrivoltaic systems to achieve synergistic production of food and energy. *Frontiers in Sustainable Food Systems*, 6, Climate-Smart Food Systems. <https://doi.org/10.3389/fsufs.2022.932018>

¹⁸² Bohler Engineering. (2024) *Addressing Community Concerns with Renewable Energy Projects*. <https://bohlerengineering.com/blog/insight/addressing-community-concerns-with-renewable-energy-projects/>

materials in rows of encapsulated panels installed over the soil and washed by rain. These materials vary according to the type of panel installed, and are sealed within the glass and aluminum panel encasement of the solar panel. Semiconductors enclosed inside the panels are either crystalline silicon (c-Si) or thin-films like Cadmium Telluride (CdTe). Metals *inside* panel encasement include silver (for contacts), copper (wiring), zinc, lead and tin (solder contacts),¹⁸³ and aluminum (external panel framing). Polymers used for bonding and protection include ethylene vinyl acetate (EVA) or other encapsulants. For CdTe panels, approximately 98% of the panel’s mass is composed of glass, polymer, and aluminum.¹⁸⁴ The extent to which such internal materials may escape encasement in normal panel function between installation and end-of-life

¹⁸³ Hutchins, M. (2019, October 26). The weekend read: A lead-free future for solar PV. pv magazine.

<https://www.pv-magazine.com/2019/10/26/the-weekend-read-a-lead-free-future-for-solar-pv/>. Note: Lead has been favored as a layer in solder due to its low melting point (160°) which places less heat stress on panels during assembly, and is usually less than 0.1% of the total module weight. Since the European Union is transitioning to lead free components as a matter of policy, manufacturers are phasing out its use.

¹⁸⁴ Weckend, S., Wade, A., & Heath, G. (2016). End-of-life management: Solar photovoltaic panels. *International Renewable Energy Agency & International Energy Agency Photovoltaic Power Systems*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf

(EOL) is a matter of long-term research, and is generally considered a risk if a panel breaks (e.g. in a storm while installed) or during removal at EOL.¹⁸⁵

The question of toxicity raises two concerns: whether the land will be suitable for flexible crop choice in the future, and whether such land will be usable for non-farm purposes (e.g. residential development with groundwater wells). Whether solar facility materials rise to the definition of toxic (i.e. pose a threat to human health) is a question of policy, and the extent to which each substance is regulated under the federal Resource Conservation and Recovery Act (RCRA).¹⁸⁶ Under some conditions, aluminum and zinc, used in panel frames, wiring, and mounting structures, can corrode and leach into soils (explored below). Generally, concentrations of external metals (aluminum and zinc) released under normal operation are below RCRA toxic thresholds, but localized accumulation near drainage points and along the “dripline” of panel rows (where rain drains off) has been observed in

¹⁸⁵ Sinha, P., Heath, G., Wade, A., & Komoto, K. (2019). Human health risk assessment methods for PV, Part 2: Breakage risks (IEA PVPS Task 12, Report T12-15:2019). International Energy Agency Photovoltaic Power Systems Programme. https://iea-pvps.org/wp-content/uploads/2020/01/Task_12-Human_Health_Risk_Assessment_Methods_for_PV_part_2.pdf

¹⁸⁶ 42 U.S.C. §§ 6901–6992k.

research.¹⁸⁷ Robinson and Meindl concluded that the concentrations of selenium, strontium, lithium, and nickel increased significantly in soil samples closer to the solar PV systems; the authors noted that even the highest observed amounts were “all well below the soil screening values” defined by the U.S. Environmental Protection Agency (EPA) and therefore did not pose an immediate environmental risk.¹⁸⁸ As for lead and cadmium, the study concluded that such internal materials are not of concern unless water invades the panel encasement (due to failed sealant or cracked glass); given that panels are continually monitored through operations and maintenance,¹⁸⁹ it is not likely a leaching situation would be allowed to go unrepaired. At any rate, the study cited found no concentrations near solar PV systems. Further, an additional study used screening-level risk assessment methods to evaluate

¹⁸⁷ Robinson, S. A., & Meindl, G. A. (2019). Potential for leaching of heavy metals and metalloids from crystalline silicon photovoltaic systems. *Journal of Natural Resources and Development*, 9, 19–24. <https://journals.ub.uni-koeln.de/index.php/JNRD/article/view/774>

¹⁸⁸ Robinson, S. A., & Meindl, G. A. (2019). Potential for leaching of heavy metals and metalloids from crystalline silicon photovoltaic systems. *Journal of Natural Resources and Development*, 9, 19–24. <https://journals.ub.uni-koeln.de/index.php/JNRD/article/view/774>

¹⁸⁹ VOLTAGE Group. (n.d.). Maintenance of large-scale solar power plants (10 MW and above). <https://voltageg.com/en/expert-blog/maintenance-of-large-scale-solar-power-plants-10-mw-and-above/>

human health risks from chemical exposure due to solar PV panels breaking in the field, finding that potential risks are generally low due to the durability of solar PV modules. Since encapsulation materials have high bond strength, the module components remain largely contained even when the module is broken, and there is limited potential for rainwater leaching of chemicals (such as cadmium or lead).¹⁹⁰

Regarding concerns about contaminants from panel cleaning, rain is generally adequate to keep panels clean for good electricity production. If panels do need to be washed, the process requires nothing more than deionized water.¹⁹¹ End-of-life panel replacement can also contribute to potential toxic releases if the job is botched, and one should not assume that care will be neglected in such cases as recycling and material recovery protocols substantially mitigate these risks.¹⁹²

¹⁹⁰ Sinha, P., Heath, G., Wade, A., & Komoto, K. (2019). Human health risk assessment methods for PV, Part 2: Breakage risks (IEA PVPS Task 12, Report T12-15:2019). International Energy Agency Photovoltaic Power Systems Programme.

https://iea-pvps.org/wp-content/uploads/2020/01/Task_12-Human_Health_Risk_Assessment_Methods_for_PV_part_2.pdf

¹⁹¹ J Racenstein. (2025). Solar panel cleaning systems overview. <https://jracenstein.com/expert-advice-learning/solar-panel-cleaning-systems-overview>

¹⁹² Rabaia, M. K. H., Abdelkareem, M. A., Sayed, E. T., Elsaid, K., Chae, K.-J., Wilberforce, T., & Olabi, A. G. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*,

Given that internal substance escape would likely be episodic, the soil health concerns should focus on external metals and their potential for leaching (noted above). Details about toxicity for aluminum and zinc are described below.

Aluminum

Aluminum (Al) is very common in soils around the world, including those in the Carolinas. In fact, the earth's crust is about 7% aluminum, and most soils are over 1% aluminum.¹⁹³ Aluminum is generally unavailable to plants as long as the soil pH is above about 5.5. In acidic soils, many forms of aluminum become more bio-available to plants, which can be toxic to many plant species.¹⁹⁴ This effect is one of the major reasons many plants do not tolerate very acidic soils. The use of aluminum building materials releases negligible amounts of aluminum during their useful life because the material is so corrosion resistant.¹⁹⁵ The aluminum frames of solar PV modules are anodized which adds a very thin hard coating of aluminum oxide to the

754, 141989.

<https://doi.org/10.1016/j.scitotenv.2020.141989>.

¹⁹³ NC State Cooperative Extension Service. (2022). *Extension gardener handbook*.

<https://content.ces.ncsu.edu/extension-gardener-handbook>

¹⁹⁴ Spectrum Analytics. (n.d.). *Soil aluminum and soil test interpretation*.

https://spectrumanalytic.com/doc/library/articles/soil_aluminum_and_test_interpretation

¹⁹⁵ Kutz, M. (Ed.). (2013). *Handbook of environmental degradation of materials* (3rd ed.). William Andrew.

<https://doi.org/10.1016/C2010-0-66227-4>

exterior of the aluminum that greatly improves aluminum's already-high resistance to corrosion. Therefore, any minute amount of aluminum that could be released by corrosion from aluminum construction materials during the life of a solar project will not materially add to the thousands or millions of pounds of aluminum naturally present in the soil of a typical solar facility. The common practice of liming soils to maintain appropriate soil pH for crop systems, alleviates most, if not all, concerns about aluminum impacting crop growth in the future.¹⁹⁶



Zinc

Zinc (Zn) is used to coat (“galvanize”) steel components to protect from rust and corrosion, including support posts for solar panels, can move into the soil.¹⁹⁷ Zinc from building material

stockpiles has been previously noted as a localized problem for peanut production in some North Carolina fields.¹⁹⁸ While it is difficult to predict in advance the degree to which this will occur, it is relatively simple to collect soil samples and monitor this situation in existing installations. Analysis of zinc is included in routine soil testing procedures used by the NCDA&CS Agronomic Services Division Laboratory. Awareness of zinc concentrations in the soil, and any spatial patterns noted with depth and distance from structures, should allow producers to determine if the field is adequate for desired crops as is. If zinc limitations exist, awareness of concentrations and spatial distribution patterns may indicate the potential for deep tillage, liming, or crop selection alternatives required for successful agricultural use. Of the agronomic crops grown in the state, peanuts are the most sensitive crop to zinc toxicity. Based on information from the NCDA&CS, there is risk of toxicity to peanuts when the zinc availability index (Zn-AI) is 250 or higher, particularly in low-pH situations. Risk increases with increasing soil test levels, especially if pH management through a liming program is not followed.

¹⁹⁶ Gatiboni, L. (2020, December 4). *Aluminum (Al) toxicity in soybean*. NC State Extension. <https://content.ces.ncsu.edu/aluminum-toxicity-in-soybean>

¹⁹⁷ American Galvanizers Association. (2023). *HDG's Contribution to Zinc Levels in the Soil Environment*.

<https://galvanizeit.org/uploads/publications/AGA-Whitepaper-Zinc-in-the-Soil-2023.pdf>

¹⁹⁸ Jordan, D. (2025, August 7). *Zinc Toxicity Peanut Notes No. 210 2025*. <https://peanut.ces.ncsu.edu/2025/08/zinc-toxicity-peanut-notes-no-210-2025/>

For most other crops, zinc toxicity does not become problematic until the Zn-Al index reaches 2,000-3,000.¹⁹⁹

Temperature Effects

Utility-scale solar PV facilities can cause changes in the air and surface temperature of the space in which they are located, with some evidence of spillover to land adjacent. The effect of solar PV facilities on surface and air temperatures is different. Solar panels shade the ground on which they are located, reducing the surface (ground) temperature from what it would be without solar panels present. However, solar panels absorb solar radiation more effectively than do typical agricultural land surfaces due to their darker color, leading to an increase in air temperature directly above the solar panels as the absorbed radiation is released as heat.²⁰⁰ The decrease or increase for surface and air temperatures, respectively, is around 2 to 4 degrees Celsius, depending on the type of land

cover in the area.^{201, 202} Large solar PV arrays absorb and reradiate heat differently than surrounding vegetation, potentially increasing local air and soil temperatures, especially at night.²⁰³

Temperature differences of 2 to 5 degrees Celsius have been observed near some installations, affecting local hydrology, evapotranspiration, and soil moisture regimes. These effects are documented, though less substantial on land outside the solar facility. One study found that an air temperature increase of 1.9 degrees Celsius directly over a solar farm dissipated to 0.5 degrees Celsius at 100 meters in horizontal distance from the solar farm, and less than a 0.3 degree increase at 300 meters.²⁰⁴

¹⁹⁹ Hardy, D. H., Tucker, M. R., & Stokes, C. (2013). Understanding the soil test report. North Carolina Department of Agriculture and Consumer Services, Agronomic Division; updated 2024, January 3). <https://www.ncagr.gov/understanding-soil-test-report/open>

²⁰⁰ Edalat, M. (2017). *Remote sensing of the environmental impacts of utility-scale solar energy plants*. UNLV Theses, Dissertations, Professional Papers, and Capstones. 3075. <http://dx.doi.org/10.34917/11156717>

²⁰¹ Fthenakis, V., & Yu, Y. (2013). Analysis of the potential for a heat island effect in large solar farms. In 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC). <https://ieeexplore.ieee.org/abstract/document/6745171>

²⁰² Barron-Gafford, G. A., Minor, R. L., Allen, N. A., Cronin, A. D., Brooks, A. E., & Pavao-Zuckerman, M. A. (2016). The photovoltaic heat island effect: Larger solar power plants increase local temperatures. *Scientific Reports*, 6, 35070. <https://doi.org/10.1038/srep35070>

²⁰³ Hernandez, R. R., Easter, S. B., Murphy-Mariscal, M. L., Maestre, F. T., Tavassoli, M., Allen, E. B., Barrows, C. W., Belnap, J., Ochoa-Hueso, R., Thornton, P. E., & Macknick, J. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29, 766–779. <https://doi.org/10.1016/j.rser.2013.08.041>

²⁰⁴ Fthenakis, V., & Yu, Y. (2013). Analysis of the potential for a heat island effect in large solar farms. In 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC). <https://ieeexplore.ieee.org/abstract/document/6745171>

Another study found that a temperature difference of 3 to 4 degrees Celsius directly above a solar farm was dissipated to the point that it could not be measured at a distance of 100 feet from the solar farm's edge.²⁰⁵ Meteorological factors can affect the range and size of any temperature effect on land nearby a solar facility, but even under very conducive circumstances the possible temperature increase for nearby land would be on the order of tenths of degrees. Studies have varied on the time at which temperature differences are most pronounced; one study noted as taking place in a desert landscape found that temperature differences were larger at night, while another study found larger temperature differences during midday; differences in weather and landscape between the study locations may be responsible for the different results.^{206, 207}

²⁰⁵ Barron-Gafford, G. A., Minor, R. L., Allen, N. A., Cronin, A. D., Brooks, A. E., & Pavao-Zuckerman, M. A. (2016). The photovoltaic heat island effect: Larger solar power plants increase local temperatures. *Scientific Reports*, 6, 35070. <https://doi.org/10.1038/srep35070>

²⁰⁶ Barron-Gafford, G. A., Minor, R. L., Allen, N. A., Cronin, A. D., Brooks, A. E., & Pavao-Zuckerman, M. A. (2016). The photovoltaic heat island effect: Larger solar power plants increase local temperatures. *Scientific Reports*, 6, 35070. <https://doi.org/10.1038/srep35070>

²⁰⁷ Fthenakis, V., & Yu, Y. (2013). Analysis of the potential for a heat island effect in large solar farms. In 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC). <https://ieeexplore.ieee.org/abstract/document/6745171>

Regarding potential heat spillover on land use adjacent to a solar PV facility, one may consider its effect on crop choice and yield, particularly corn which as a warm season crop requires a measure of cooling in nighttime temperature. While crop research shows some yield reduction in higher nighttime temperatures generally (caused by factors unrelated to a solar facility), the study cited above (Fthenakis et al.) found that at night the solar PV site cools completely, thus any daytime increases do not affect the cool night cycle of the crop.²⁰⁸

Because shading changes the temperature and light near the ground, it may influence how well plants recover and shift where local species are found.²⁰⁹ However, the magnitude of these effects varies with ground cover, panel height, and ventilation beneath panel arrays. Some studies indicate that vegetated solar sites can mitigate heat buildup, while bare-soil installations would intensify thermal contrasts (i.e. the site gets hotter).²¹⁰

²⁰⁸ Fthenakis, V., & Yu, Y. (2013). Analysis of the potential for a heat island effect in large solar farms. In 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC). <https://ieeexplore.ieee.org/abstract/document/6745171>

²⁰⁹ Rabaia, M. K. H., Sayed, H. D., & others. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment*, 754, 141989. <https://doi.org/10.1016/j.scitotenv.2020.141989>

²¹⁰ Bertel, R., Choi, C. S., Macknick, J., McCall, J., & Ravi, S. *The extent of vegetation-driven panel cooling and consequent increase in electricity generation from solar PV sites depend on climate and soil properties. AGU 2021 Fall*

To the extent that increased temperatures is of concern for the facility and surrounding parcels, accepting such temperature dynamics further supports local facility permitting requirements and sedimentation risk management inherent in ground cover maintenance. Dual-use land designs such as agrivoltaics also address this issue.^{211,212}

PFAS

In recent years, public awareness and concern around per/polyfluoroalkyl substances (PFAS), long-lasting chemicals linked to health risks, has increased. However, PFAS are not commonly used in solar panels, and most modern solar panels use safe alternatives. While certain parts of panels like backing materials, adhesives, and coatings could theoretically be made of PFAS, in practice, they usually use non-hazardous silicon materials. Further, no research has found evidence of PFAS leaking from solar panels during operation or disposal. Everyday items like construction materials or

Meeting Meeting New Orleans, LA, (). Retrieved from <https://par.nsf.gov/biblio/10341234>

²¹¹ USDA Climate Hubs. (n.d.). Agrivoltaics: Pairing solar power and agriculture in the Northwest.

<https://www.climatehubs.usda.gov/hubs/northwest/topic/agrivoltaics-pairing-solar-power-and-agriculture-northwest>

²¹² Williams, H. J., Hashad, K., Wang, H., & Zhang, K. M. (2023). The potential for agrivoltaics to enhance solar farm cooling. *Applied Energy*, 337, 120610.

<https://doi.org/10.1016/j.apenergy.2022.120478>

outdoor fabrics are more likely to release PFAS than solar panels.²¹³

3.2 Decommissioning Solar PV Facilities

If land used for a solar facility is to be returned to agricultural or another use in the future, it will be necessary to remove the solar components from the land. This process is known as decommissioning. Decommissioning is basically the construction process in reverse; it involves removal of the solar panels, breakup of support pads, removal of access roads, replacement of any displaced soil, and revegetation.

In assessing the decommissioning task, it's essential to first catalog the physical assets that the solar developer must account for in its decommission plan requirement. The solar panels rest upon racks typically fashioned from steel or aluminum. These support structures are anchored to the ground by galvanized steel posts. Critically for landowners concerned about site reclamation, these posts are usually driven directly into the earth to a depth of 6 to 8 feet, a process that intentionally avoids the use of concrete.

²¹³ Anctil, A. (2020). Facts About Solar Panels: PFAS Contamination. *University of Michigan Graham Sustainability Institute*. <https://graham.umich.edu/media/pubs/Facts-about-solar-panels--PFAS-contamination-47485.pdf>

The primary use of concrete is limited to the inverter/transformer pads. These pads, generally 10 feet by 20 feet, serve as the foundation for the equipment that converts the solar power. A rule of thumb is no more than one pad per MW capacity. However, some advanced sites are utilizing pre-cast concrete or steel skids that sit *above grade* on easily removable helical steel piers, further reducing the amount of poured concrete on site.

The electrical infrastructure is straightforward: much of the wiring is run above-ground and secured to the underside of the racking. The remaining cabling is buried only 2 to 3 feet deep, either direct-bury cable or housed in 2 to 6 inch PVC conduit, which requires minimal subsoil disturbance. As “racking” technology has advanced over the years, developers have greater ability to contour panel rows with the land, which reduces the need to grade land and displace soil,²¹⁴ which would likely reduce reclamation costs.

Soil and site integrity restoration are mandated by law. The NCDEQ requires developers to hold permits and implement strict soil erosion and sedimentation control plans. These measures are continuously inspected until permanent vegetative ground cover is established, protecting the site's most

²¹⁴ Westwood Professional Services. (2025). Adapt to the Solar Landscape: Terrain-Following Trackers. Westwood Professional Services. <https://westwoodps.com/recent-blog-posts/adapt-solar-landscape-terrain-following-trackers>

valuable asset: its soil. Similarly, the South Carolina Department of Environmental Services (SCDES) administers a general National Pollutant Discharge Elimination System permit, or “stormwater construction permit” required for land disturbance in the state. Applicants must submit project plans that show the compliance techniques for erosion control and sediment runoff.²¹⁵ Well-drafted leases are the final protection, as they should explicitly detail the allowable construction techniques and the exact location and material of all site infrastructure.

In 2023, North Carolina passed solar decommissioning legislation and subsequent regulations that apply to utility-scale solar projects (a ground-mounted solar project capable of generating 2 MW AC or more directly connected to the local or regional electrical grid with the ability to deliver power to the electrical grid).²¹⁶ The owner of a utility-scale solar project is responsible for proper decommissioning and all costs associated with decommissioning within one year of the project ceasing operations. The minimum decommissioning requirements include (1) disconnecting the PV facility from

²¹⁵ South Carolina Department of Environmental Services. (2025). NPDES permit - stormwater. SC.gov.

<https://des.sc.gov/programs/bureau-water/national-pollutant-discharge-elimination-system-npdes/npdes-permit-stormwater>

²¹⁶ See generally N.C. Sess. Laws 2023-58 (codified as various sections of N.C. Gen. Stat.)

the grid, (2) removing all equipment and properly disposing of all elements which are not practically capable of being reused or recycled, and (3) restoring the property (i) as nearly practicable to its condition before the project was sited or (ii) to an alternative condition agreed upon in a written contract or lease agreement between the landowner and project owner. Additionally, the owner of the project must submit a decommissioning plan to the NCDEQ and establish financial assurance in an amount acceptable to the Department for covering decommissioning costs.

This significant feature of the decommissioning legislation and regulations is that the owner of a solar PV facility must submit to the NCDEQ a decommissioning plan backed by a financial guarantee of funds available to cover the cost of decommissioning. Such financial guarantees may come in the form of trust fund, surety bond guarantee of payment to trust fund, letter of credit, bond, insurance, a “financial test,” or a corporate [parent] guarantee.²¹⁷ Such instruments are valued based on the cost estimate of decommissioning - less salvage value determined according to market at the time the decommission plan is submitted (or submitted every five years) - with such costs including estimates of personnel time and expenses, transportation of materials to

²¹⁷ 15A N.C. Admin. Code 01V .0101-.0107

the receiving facility or location, such as the nearest existing recycling or disposal facility, and the fees charged by the receiving facility or location to accept the materials.²¹⁸

The SCDES requires that large solar facilities (greater than 13 acres) must register information with the Department that includes the projected date of decommissioning and a signed agreement between the owner and the landowner that complies with post-decommissioning land restoration requirements, among other elements.²¹⁹ Registrations must be updated every five years or when ownership changes. Five years before the system’s end-of-life date, the registrant must submit a decommissioning plan for approval, which must be updated if facility changes occur that require a deviation from the approved decommissioning plan, including the cost estimate.²²⁰

The decommissioning plan elements include but are not limited to the proposed number of solar panels for decommissioning, a list of all components of the solar energy system to be properly recycled or disposed of, the timeframe for decommissioning, the tasks and equipment involved in the decommissioning process, a detailed final estimate of the cost of recycling or disposing of all components in the

²¹⁸ 15A N.C. Admin. Code 01V .0101-.0107

²¹⁹ S.C. Code Regs. § 61-107.20.D

²²⁰ S.C. Code Regs. § 61-107.20.E

solar energy system, and a financial assurance mechanism that will be used to meet the requirements of the cost estimate.²²¹ Similar to North Carolina, the mechanism may include cash, insurance, trust funds, surety bonds, letters of credit, certificates of deposit, and financial tests to ensure that the funds necessary to meet the costs of closure and corrective action for known releases will be available whenever needed.²²²

Decommissioning will be considered complete once all elements of the system are removed and properly disposed of, or the property where the installation is located has been reasonably restored.²²³ The regulation defines reasonable restoration to include soil stabilization and revegetation of the ground cover disturbed by the installation.²²⁴

The materials recovered in the decommissioning process may have significant economic value, which are deducted from the estimated costs of decommissioning.²²⁵ Some engineering analyses have indicated that the salvage value of recovered materials is

more than enough to pay for the removal of all the materials and to return the site to its pre-construction state, though estimates vary.^{226, 227}

One example of a salvage value estimate was offered by Duke Energy Progress in its facility decommission report filed in 2017, specifically for its Elm City solar PV facility. The report estimated the project's salvage value to be \$1.9M, based on a steel scrap value of \$140.37/ton, an aluminum scrap at \$0.40/lb, and copper scrap at \$1.70/lb. Accounting for that salvage value, the net decommission/restoration cost of the project was estimated to be \$4,419,000.²²⁸ Updated figures for scrap metal prices (by facility and averaged) can be sourced at www.iscrapapp.com, with a November 2025 visit to the site revealing averaged steel scrap at \$165.74/ton; aluminum scrap at \$0.48/lb; copper (tubing) scrap at \$3.34/lb.²²⁹

²²¹ S.C. Code Regs. § 61-107.20.E

²²² S.C. Code Regs. § 61-107.20.F

²²³ S.C. Code Regs. § 61-107.20.E

²²⁴ S.C. Code Regs. § 61-107.20.B

²²⁵ Fthenakis, V., Zhang, Z., & Choi, J.-K. (2017, June). Cost optimization of decommissioning and recycling CdTe PV power plants. In 2017 IEEE 44th Photovoltaic Specialists Conference (PVSC). <https://ieeexplore.ieee.org/document/8366091>

²²⁶ HDR Engineering, Inc (2025).

Decommissioning Plan for White Palmetto Solar Energy System.

<https://www.sumtersc.gov/sites/default/files/uploads/Departments/Planning/BoardsCommissions/BZA/2025/May/exhibit-11-decommissioning-plan.pdf>

²²⁷ Sandifer, C. (2021). Rowan County, North Carolina Okra Solar Site Decommissioning Report.

<https://www.rowancountync.gov/DocumentCenter/View/29005/Exhibit-6-Decommissioning-Report-PDF>

²²⁸ Burns & McDonnell Eng'g Co. (2017)

Decommissioning Cost Estimate Study (prepared for Duke Energy Progress),

<https://www.scribd.com/document/527627021/ViewFile-1>.

²²⁹ iScrap App. (n.d.). *iScrap App*.

<https://www.iscrapapp.com>

An example of a general estimate, shows that solar decommissioning costs can range from as low as \$300/kilowatt (kW) if a credit of \$40/kW is applied for repurposing or reselling the modules up to as high as \$440/kW if an additional cost of \$100/kW is incurred for recycling the modules.²³⁰

²³⁰ Curtis, T., Heath, G., Walker, A., Desai, J., Settle, E., & Barbosa, C. (2021). Best practices at the end of the photovoltaic system performance period. *National Renewable Energy Laboratory* (NREL/TP-5D00-78678). National Renewable Energy Laboratory. <https://www.nrel.gov/docs/fy21osti/78678.pdf>

Below is a component breakdown of decommissioning estimates:

Example cost estimates for decommissioning per 1-MW fixed tilt rack solar PV system:²³¹

Item	Cost Estimate (\$/MW)
Make arrangements for recycling or sale of used items	\$2,000
Provide lavatories and safety items	\$5,000
Rent containers to sort recyclables and disposables	\$5,000
Remove and bundle array wiring and AC wiring	\$25,000
Remove and palletize solar PV modules	\$25,000
Dismantle racks and containerize	\$50,000
Remove and palletize combiner boxes and disconnects	\$25,000
Remove conduit and containerize	\$25,000
Remove and disassemble inverter	\$50,000
Remove transformer	\$75,000
Transportation to recycling center	\$5,000
Transportation to landfill	\$5,000
Hazardous waste disposal	\$5,000
Install temporary fence (\$20/ft)	\$10,000
Break up and remove concrete pads for ground-mounted systems	\$25,000
Remove ground screws and power poles	\$40,000
Remove temporary fence	\$5,000
Grading	\$20,000
Seeding of disturbed areas	\$16,000

²³¹ Curtis, T., Heath, G., Walker, A., Desai, J., Settle, E., & Barbosa, C. (2021). Best practices at the end of the photovoltaic system performance period. *National Renewable Energy Laboratory* (NREL/TP-5D00-78678). National Renewable Energy Laboratory. <https://www.nrel.gov/docs/fy21osti/78678.pdf>

Salvage Values:	
Solar PV modules	\$ (40,000)
Copper wire and parts	\$ (20,000)
Transformer and switchgear	\$ (15,000)
Aluminum rack and parts	\$ (15,000)
<u>Total for ground-mounted system</u>	\$368,000

The figures presented in the above table are for illustration only.



Conclusion

As noted at the outset, the purpose of this white paper is to explore the challenges of land use change between farm use and solar development, with illustrative examples from the Carolinas and suggested approaches to measure the economic and social impact of such changes. To the extent that such changes are considered competitive, it is important to place the trade-offs in the context of landowner and local government decision-making, and the extent to which short and long-term agricultural productivity and traditional expectations about undeveloped landscapes are impacted by solar development. As noted throughout, the concerns of rural residents - both owners of potential development sites and the farmers that produce on rural lands - are of valid concern and must be thoughtfully addressed. The goal of this white paper has been to further the dialogue in rural communities on these concerns with reference to available research into the economic and ecological impacts of such development, making note of areas for needed further study.