Planning and Zoning for Solar in North Carolina

2014

Adam Lovelady

UNC
SCHOOL OF GOVERNMENT

The School of Government at the University of North Carolina at Chapel Hill works to improve the lives of North Carolinians by engaging in practical scholarship that helps public officials and citizens understand and improve state and local government. Established in 1931 as the Institute of Government, the School provides educational, advisory, and research services for state and local governments. The School of Government is also home to a nationally ranked graduate program in public administration and specialized centers focused on information technology and environmental finance.

As the largest university-based local government training, advisory, and research organization in the United States, the School of Government offers up to 200 courses, webinars, and specialized conferences for more than 12,000 public officials each year. In addition, faculty members annually publish approximately 50 books, manuals, reports, articles, bulletins, and other print and online content related to state and local government. Each day that the General Assembly is in session, the School produces the *Daily Bulletin Online*, which reports on the day's activities for members of the legislature and others who need to follow the course of legislation.

The Master of Public Administration Program is offered in two formats. The full-time, two-year residential program serves up to 60 students annually. In 2013 the School launched MPA@UNC, an online format designed for working professionals and others seeking flexibility while advancing their careers in public service. The School's MPA program consistently ranks among the best public administration graduate programs in the country, particularly in city management. With courses ranging from public policy analysis to ethics and management, the program educates leaders for local, state, and federal governments and nonprofit organizations.

Operating support for the School of Government's programs and activities comes from many sources, including state appropriations, local government membership dues, private contributions, publication sales, course fees, and service contracts. Visit www.sog.unc.edu or call 919.966.5381 for more information on the School's courses, publications, programs, and services.

Z. Smith Reynolds
FOUNDATION

This publication was made possible by the generous support of the Z. Smith Reynolds Foundation.

The Z. Smith Reynolds Foundation (ZSR) is committed to improving the quality of life of all North Carolinians. ZSR invests in statewide, regional and community-based organizations that are dedicated to building an inclusive, sustainable, and vibrant state. The groups that ZSR supports both work to build healthy, robust communities at the local and regional level and engage in education, civic dialogue and advocacy around issues of importance to communities and to North Carolina. ZSR currently focuses on the areas of community economic development, environment, public education, social justice and equity, and strengthening democracy. The foundation is a 76-year-old private foundation based in Winston-Salem, North Carolina. For more information, visit www.zsr.org.

18 17 16 15 14 1 2 3 4 5

Contents

Acknowledgments

This publication was enriched by informative site visits, generous comments, and insightful critiques. Among others, I thank the following individuals: Sam Beck, Clay County, North Carolina; Kyle Brown, Camp Lejeune; Tommy Cleveland, North Carolina Solar Center; Brandi Deese, City of Laurinburg, North Carolina; Miriam Makhyoun and Michael Fucci, North Carolina Sustainable Energy Association; Michael McDonough; Greg Ness, FLS Energy; Gary Ouellete, City of Jacksonville, North Carolina; Autumn Radcliff, Henderson County, North Carolina; Lance Williams, Strata Solar. Additionally I thank my colleagues at the School of Government, especially David Owens and Richard Ducker, for their guidance and comments.

Introduction

Across North Carolina—from Currituck County on the coast to Clay County in the mountains—solar energy systems are filling pastures and cladding rooftops. The rapid rise of the solar industry in North Carolina has many communities debating how to handle this new land use. How do we plan for solar energy investments? How do we facilitate responsible solar development? What are the potential land use impacts, and how can we address them? These broad questions call for analyzing solar technologies and development, considering the legal framework for zoning and subdivision regulation, and balancing multiple policy considerations. *Planning and Zoning for Solar in North Carolina* provides a foundation for communities to begin to evaluate solar development and craft appropriate ordinances.

This publication focuses on North Carolina law and North Carolina communities. Some issues—such as limits on zoning for residential accessory solar development—are specific to the state. But many other issues are common to solar development across the United States. For that reason model ordinances crafted in other states are presented here, and the discussions and lessons highlighted here will apply in other states. In this document, references and citations are to North Carolina communities unless otherwise noted.

The impetus for *Planning and Zoning for Solar* was the many questions posed by North Carolina local planning and zoning officials as they seek to update ordinances to better manage solar development in their communities. Research for this publication included a survey of existing materials and resources, a review of North Carolina solar ordinances (including the North Carolina Template Solar Ordinance) and model ordinances from other states, discussions with local zoning officials and solar industry professionals, and site visits to solar developments around the state. Thus the information presented herein should support informed policy-setting and decision-making by community leaders as they navigate this new topic of local government land use law and regulation.

In summary, this report highlights the issues local communities face as they consider important policy questions about planning and zoning for solar. Questions pertaining to planning concerns might include the following:

- How does solar fit into community planning efforts?
- How might a local government pursue solar development?
- How can solar development be streamlined and incentivized?

Questions related to zoning might include these:

- What are the land use impacts of solar?
- How is solar development defined and distinguished?
- Where is solar appropriate?
- What should the standards for principal solar uses be?
- What should the standards for accessory solar uses be?
- How can solar development be balanced with competing interests in the ordinance?

Issues related to solar energy systems extend beyond shorter term zoning and planning concerns. For example, what ways can communities enhance and preserve solar access for current and future solar development?

The sections that follow examine these different aspects of planning and zoning for solar. Part I, “Understanding Solar,” provides an introduction to solar technology and trends in the solar industry in North Carolina. Part II, “Planning for Solar,” evaluates options available for communities to plan for and facilitate public and private investment in solar development. Part III, “Zoning for Solar,” outlines issues that arise in zoning for solar: potential land use impacts, definitions of solar uses, standards for solar farms, standards for accessory solar uses, and the potential conflicts between solar and other zoning issues. Part IV, “Solar Access and Solar Siting,” extends the discussion from the prior section with an analysis of how local development regulation may protect and enhance solar exposure for current or future solar development. The last section provides additional resources.

Part I: Understanding Solar

North Carolina

Solar photovoltaic (PV) and solar thermal systems are springing up all around the state. As of June 2013, North Carolina had 245 megawatts of utility scale solar installations in operation and an additional 1,102 megawatts planned, according to the financial and industry analyst SNL.[1] The pace of installation has greatly increased. North Carolina ranked second in the country, behind only California, for solar PV capacity added in 2013.[2]

Several factors drive solar development in North Carolina, including falling prices of solar panels and installation, market demands from private development and military bases for renewable energy, state and federal incentives, standard offer contracts by the utilities, and the state renewable energy portfolio standard enacted in 2007. The portfolio standard mandates that electric utilities derive 6 percent of their retail sales from renewable or energy efficient sources or both by 2015. The standard rises to 10 percent in 2018 and 12.5 percent in 2021.[3]

Photovoltaic panels (or modules), here on a solar farm, convert sunlight into electricity.

1. Charlotte Cox, "Solar PV Posts Best Q1 Capacity Growth of All Time," SNL, June 11, 2013, www.snl.com.

2. "Record 2013 Solar PV Installations Promotes U.S. to Strongest Market Outside Asia-Pacific, According to NPD Solarbuzz," NPD Solarbuzz, Press Release, Jan. 8, 2014, www.solarbuzz.com.

3. "Renewable Energy and Energy Efficiency Portfolio Standard (REPS)," North Carolina Utilities Commission, www.ncuc.commerce.state.nc.us.

Solar Basics

PV and Thermal

The current solar industry in the Southeast has two broad categories of solar energy systems: solar photovoltaic systems and solar thermal systems. Solar photovoltaic, or PV, panels convert solar energy into electricity that may be used on-site or fed into the electric grid. Solar thermal panels absorb solar energy as heat and transfer that heat for common household or commercial purposes (that is, hot water or space heating). PV and thermal panels are very similar in land use impacts and are commonly treated the same under zoning regulations. Typical PV panels and typical thermal panels are comparable in size, profile, and appearance. Both technologies are more effective when the panel is angled toward the sun, but the angle is more critical for solar thermal performance. Thus, roof-mounted solar thermal panels may benefit from a steeper pitch.

Another category of solar energy involves concentrating solar rays for energy production. Such systems do so by using a series of large mirrors to concentrate sunlight for PV electric production or to heat liquid for steam energy generation. Concentrating solar power systems demand the consistent, intense sunlight typically found in desert regions, so such systems are less common in the southeastern U.S.

Cell, Panel, Array, Farm

A solar energy system is composed of a series of linked components. For PV systems, the most basic component is the solar cell. Solar cells convert solar energy into electricity. Cells are typically square or circular and 4–6 inches across. Commonly cells are arranged together into flat, rigid modules—sometimes called solar panels—that hold about forty cells. (Newer technologies

Solar thermal panels atop the Proximity Hotel in Greensboro. The hotel earned LEED® Platinum certification from the U.S. Green Building Council.

Solar cells are combined into solar panels, solar panels are combined into solar arrays, and solar arrays are combined into a solar farm, such as in this solar farm in Chatham County.

link thin, flexible solar cells into films that may be applied directly to building components.)[4] Traditional panels may be installed independently, or several panels may be linked and mounted together as a solar array. Multiple arrays may be linked together into a solar farm. In order to be connected to the electric grid, PV solar systems require equipment called inverters to change the DC electric current produced by the cells into AC electric current usable in the grid. An inverter can be as small as a paperback book or as large as a compact car, depending on the system size and design. Smaller inverters can be mounted on poles and scattered throughout a solar farm, or several large, pad-mounted inverters may be used, consolidating the equipment into a few locations. Wiring, of course, must link the panels to inverters and inverters to power lines.

So what does all of this mean with regard to scale? How many panels does a house need? Obviously the performance of a solar PV system will depend upon design, technology, and solar exposure, but there are some general rules of thumb. An average North Carolina home would need 45–50 typical solar panels to offset the energy consumed. Most residential solar energy systems have fewer panels and provide some but not all of the energy consumed on-site.

What about solar farms? How big is a 1-megawatt project? The panels of a 1-megawatt PV system can produce 1 megawatt (1 million watts) of electricity under standard testing conditions (peak sun and cool modules). This is the system's nameplate capacity. Even though a solar farm in a field is not in standard testing conditions—the sun angle shifts through the day and the seasons, clouds shade the field, and temperatures vary—its nameplate capacity remains the gauge of the size and productivity of the system. A typical solar farm with a nameplate capacity of 1 megawatt

4. "Solar Energy Technology Basics," U.S. Department of Energy, http://energy.gov.

would occupy 6–10 acres of land and be composed of 3,000–4,000 solar panels. A 1-megawatt solar farm could power approximately one hundred average homes. The scale can be much larger, of course. In North Carolina, solar developers have constructed farms as large as 15 megawatts and have planned farms as large as 75–100 megawatts, covering hundreds of acres.[5] Such large-scale farms are already in operation in California.

For solar thermal systems, panels are constructed with tubes of liquid inside. Like PV solar, solar thermal panels may be installed independently or mounted together as an array. Several arrays may be arranged together as a large-scale solar thermal installation. Whereas PV solar requires a network of wires, solar thermal requires a network of pipes to convey the heat into the building for use.

Mounting and Tracking

A property owner may install solar arrays in three distinct ways: ground-mounted, roof-mounted, or building-integrated. Each of these methods is just what the name suggests, but the land use impacts and relevant regulations may differ depending on the type of installation.

Roof-mounted solar energy systems are mounted atop some structure. The common image is of a residential rooftop with solar panels installed on the south-facing roof slope. These are fairly modest installations to offset a portion of the residential energy demands. They can create some aesthetic impacts. Flat commercial rooftops offer another significant opportunity for solar installations. Panels may be installed flat (flush with the roof) or may be tilted to increase solar production. Solar installations on flat rooftops are often designed so they are not visible from neighboring property or the adjacent right-of-way.

Ground-mounted solar energy systems are installed onto racks, poles, or other equipment specifically constructed to support the solar energy array. A ground-mounted array potentially

Flush-mounted solar panels on a pitched roof.


Ground-mounted PV panels.

5. Andrew Engblom, "Strata Solar Plans Major New Solar Project in North Carolina," SNL, Feb. 11, 2013, www.snl.com.

Building-integrated solar panels—in this case, a PV awning.

could be as short as 4 feet and as tall as 20–30 feet (for an array over a parking lot, for example). Because a ground-mounted system is often plainly visible, it can raise aesthetic concerns and spur neighbor opposition. And because they are typically shorter than roof-mounted systems, shading from nearby buildings or vegetation can be a greater concern for ground-mounted systems.

Finally, solar energy systems may be installed as a common building component. This is called building-integrated solar. The solar awning is a prevalent building-integrated solar installation. As solar technology advances, solar shingles, window films, wall coverings, and other creative solar applications may be more common. From a regulatory perspective, building-integrated solar may be treated the same as the underlying building component (shingle, awning, window, siding).

Solar arrays may be installed as fixed systems or tracking systems. Fixed systems are mounted on stationary racks. Developers set the angle and orientation of the stationary system to maximize sun exposure (through the day and the seasons) while balancing other factors such as density of rows, wind force, and visibility. Tracking systems are equipped with mechanical components so the panels track the sun through the sky on either one or two axes. Tracking systems are more efficient than fixed systems, but fixed systems may be more cost-effective and reliable.

Scale of Solar

Solar development is occurring at multiple scales for different energy users. The scale may range from a small solar panel on a streetlight or traffic sign to a solar farm hundreds of acres in size. Principal energy users may be residential, commercial, or utility customers. Moreover, the financial and ownership arrangements for solar projects may involve a landowner, project owner, energy purchaser, and end user.

A residential-scale solar energy system typically is installed on the roof, although it may be ground-mounted. The military has installed 2,000 solar hot water panels on military homes at

Residential-scale solar provides some or all of the energy needs of a residence. These residential solar installations in Durham incorporate PV and thermal.

Camp Lejeune, providing up to 75 percent of household hot water.[6] Some private developers are now offering solar with new home construction.[7] An average residential-scale project may have ten to thirty solar panels.

A commercial-scale solar project is an accessory use supporting the primary commercial use on the site. Examples include significant rooftop installations and a variety of ground-mounted solar developments. Raleigh-based First Citizens Bank installed 7,000 solar panels (a 1.7-megawatt system) atop its corporate data center in Raleigh.[8] Ikea installed a 1.1-megawatt system covering 122,000 square feet of the roof of its Charlotte store.[9] Prestage Farms installed a 7-acre solar thermal system (2,100 thermal panels) at its food processing facility in Saint Pauls. At the time of installation, it was touted as the nation's largest solar thermal farm.[10]

Utility-scale solar projects are solar farms. They are the principal use on the property and may range in size from just a few acres to hundreds of acres. There is no bright line, however, between a commercial-scale project and a utility-scale project. Utility-scale solar projects typically are developed for the energy to be sold to a regulated utility and fed into the electric grid. But these large-scale projects may be tied directly to an end user. Near Maiden, North Carolina, Apple Inc.

---

6. Sami Grover, "Camp Lejeune's Groundbreaking Solar Surge," North Carolina Sustainability Center, http://ncsustainabilitycenter.org.

7. "Meritage Homes, EchoFirst and Southern Energy Management Partnering to Bring Complete Solar Solutions to North Carolina Homes," Southern Energy Management, Press Release, May 8, 2012, www.southern-energy.com.

8. Chris Baysden, "First Citizens Bank Installing Solar Panel System," *Triangle Business Journal*, Dec. 19, 2011, www.bizjournals.com/triangle.

9. Alison Angel, "Ikea Charlotte Plugs in Solar System," *Triangle Business Journal*, June 6, 2013, www.bizjournals.com/charlotte.

10. "Nation's Largest Solar Thermal Farm at Prestage Foods Dedicated," Prestage Farms, Press Release, Apr. 3, 2012, www.prestagefarms.com.

Commercial-scale solar commonly makes use of the large, flat roofs of today's commercial buildings. PV or thermal panels may be installed flat or pitched to increase energy production.

Solar farms are large-scale solar installations such as Apple's farm near Maiden, North Carolina.

has installed a 100-acre, 20-megawatt solar facility beside its data center and is installing another 100-acre, 20-megawatt solar facility there. At the time of installation, Apple claimed this as the nation's largest end user–owned, on-site solar array.[11]

Regulatory Context

Solar development triggers a mix of business and regulatory hurdles far beyond local planning and zoning. Solar developers must manage real estate deals, financing, owner and operator relationships, power purchase agreements, construction details, electric grid interconnection, and ongoing operations and maintenance. Various utility regulations and approvals apply as well.

Additionally, a variety of development regulations—related to, but distinct from, zoning—may affect development of solar. The North Carolina Building Code and Electric Code (and Plumbing Code for solar thermal) apply to these installations. Standard erosion and sediment control regulations, as well as stormwater provisions, also apply. Zoning is just one piece of the regulatory puzzle.

11. "Powering Our Facilities with Clean, Renewable Energy," Apple Inc., www.apple.com.

Part II: Planning for Solar

The Local Plan

Through the comprehensive planning process, towns, cities, and counties capture a picture of the present conditions and establish a vision for their communities: What are the current opportunities and threats? What are the goals for the future? And how will the community achieve those goals? Energy in general—and solar in particular—is an essential component of any contemporary comprehensive plan. Addressing solar energy production can support common planning goals, including increased use of local and renewable energy sources, sustainable building practices, efficient investment of public dollars, and local economic development.

Increasingly, local planning efforts are including energy aspects. In northern Virginia, several jurisdictions have adopted energy-specific plans.[1] Arlington County, for example, adopted a Community Energy Plan, a straightforward policy document concerning energy in buildings, transportation, and county government as well as renewable energy and district energy.[2] In addition to a county-wide community energy strategy, Loudoun County produced and adopted an Integrated Energy Management Plan for Moorefield Station, a terminus station for a new metropolitan transit line extension.[3] The plan is intended as a framework for energy and sustainability infrastructure for the significant growth expected to surround the new transit station.

Aspects of solar energy production also may be incorporated into broader comprehensive plans. In North Carolina, Raleigh's Comprehensive Plan includes policy statements to support

Raleigh has converted land near a wastewater treatment plant into a solar farm.

1. "Community Energy Planning Northern Virginia," Northern Virginia Regional Commission, www.novaregion.org.

2. Community Energy Plan, Arlington County, Virginia, June 2013, http://freshaireva.us.

3. Integrated Energy Management Plan, Loudoun County, Virginia, Feb. 29, 2012, www.loudoun.gov; see also "Moorefield Station Integrated Energy Management Plan," Loudoun County, Virginia, www.loudoun.gov.

the development and application of renewable energy technologies such as solar energy (Policy EP 1.10) and to remove regulatory barriers to solar and other technologies (Policy PU 6.7). Action statements call for Raleigh to study and consider incentives for homebuilders and homeowners to install solar and other co-generation technologies (Action EP 1.8), explore the use of public facility rooftops for solar energy systems (Action EP 1.11), explore potential solar access regulations (Action EP 1.11), and implement solar arrays at the Neuse River Waste Water Treatment Plant once the farm fields are no longer suitable for bio-solid application (Action PU 4.5).[4]

Beyond the planning documents, local governments may lay the groundwork for solar development through public investment, by reducing regulatory hurdles, and by creating incentives for solar projects.

Public Opportunities

Solar development presents a significant opportunity for local governments. Solar energy is a local renewable resource that is largely untapped. Local governments may institute public solar development and facilitate private solar development. In the public context, local government property (such as wastewater plants, closed landfills, and brownfields) could be used to foster solar development. Moreover, existing or planned public buildings can support rooftop and accessory solar development, either as stand-alone projects or as part of a more comprehensive energy efficiency upgrade. Given the long-term nature of public building investment, renewable energy and energy efficiency are commonly net benefits for local government buildings. In Cary, North Carolina, the newly constructed Fire Station 8 includes solar thermal and photovoltaic (PV) panels.[5] As recommended in the city's comprehensive plan, the City of Raleigh installed a 1.3-megawatt solar energy system on 10 acres at its Neuse River Wastewater Treatment Plant.[6] Raleigh also installed a 250-kilowatt array on the roof of the city's E.M. Johnson Water Treatment Plant.[7]

Brownfield sites—contaminated former industrial or waste sites—offer a particularly significant opportunity for solar development: they are flat, they have limited development potential otherwise, and they have good interconnection with the electric grid. Redevelopment of brownfields with solar energy projects can bring new investment to underperforming sites, increase value for property owners, and generate tax revenues for the local government.[8]

4. 2030 Comprehensive Plan, City of Raleigh, adopted Oct. 7, 2009, amended Apr. 5, 2011, www.raleighnc.gov.

5. Andrew Kenney, "Cary Tests 'Green' Tech in New Fire Station," *Raleigh News & Observer*, June 23, 2013, www.newsobserver.com.

6. "City of Raleigh Opens New 10 Acre Solar Power Facility," *The Raleigh Telegram*, Mar. 16, 2012, http://raleightelegram.com.

7. "E.M. Johnson Water Treatment Plant Produces Energy through a Rooftop Solar Array," City of Raleigh, www.raleighnc.gov.

8. "RE-Powering America's Land," U.S. Environmental Protection Agency, www.epa.gov.

Streamlined Regulation

In the private context, local governments can streamline the process for solar development in a variety of ways. Local regulation can either inhibit solar development or facilitate it. Zoning approvals and building permits (potentially including building, electrical, and plumbing) are necessary to ensure that solar development is safe and adheres to policies and requirements. But permitting costs may be reduced and processes streamlined. Some local governments offer checklists or permit maps for the approvals required for solar development. A report from the Solar America Board for Codes and Standards outlines an expedited permit process for PV systems.[9] Solar-friendly local governments may streamline the permitting process, provide a comprehensive checklist for approvals, and institute administrative approvals where appropriate.[10] Additionally, local government documents and resources may be helpful to solar developers evaluating project sites. Common online GIS resources will assist solar developers in identifying prime lands for solar development. Some communities have even mapped solar incidence, identifying areas of good solar exposure.[11]

Incentives for Solar

Local incentives also may facilitate solar development. North Carolina municipalities are authorized to establish programs to finance and purchase renewable energy systems and energy efficiency improvements, including revolving local funds and loan loss reserve funds.[12] Cities and counties may "adopt ordinances to grant a density bonus, make adjustments to otherwise applicable development requirements, or provide other incentives" to encourage development with reduced energy consumption.[13] Local governments also may support environmentally friendly building practices more broadly with reduced or rebated building permit fees for buildings that meet certain green building certification standards.[14] Solar energy production is one aspect of such green building certifications. A 2012 survey found modest use of these incentives by local governments around the state.[15]

Solar may in fact serve to mitigate unrelated impacts. In Raleigh, the additional impervious surface of excessive parking (150 percent over the required parking) must be mitigated. Among the options for mitigation is to "[p]rovide elevated solar powered arrays in lieu of required landscaping plantings for the parking area above the maximum. The solar arrays shall be installed above a minimum of 50% of the parking area above the maximum."[16]

Solar may be incentivized in a variety of ways—even used as a mitigating factor for other aspects of development.

---

9. "Expedited Permit Process Report, Revision 2," Solar America Board for Codes and Standards, July 2012, www.solarabcs.org.

10. "Project Permit: Simplifying Solar Permitting," http://projectpermit.org.

11. "Solar Briefing Papers 2: Solar Mapping," American Planning Association, 2012, www.planning.org.

12. N.C. Gen. Stat. (hereinafter G.S.) § 160A-459.1, www.ncleg.net.

13. G.S. 160A-383.4, www.ncleg.net.

14. G.S. 160A-381(f), www.ncleg.net.

15. David W. Owens and Dayne Batten, "2012 Zoning Survey Report: Zoning Adoption, Administration, and Provisions for Design Standards and Alternative Energy Facilities," *Planning and Zoning Law Bulletin* No. 20, July 2012, http://shopping.netsuite.com.

16. Raleigh, N.C., Unified Development Ordinance § 7.1.2.D., www.raleighnc.gov.

Part III: Zoning for Solar

Zoning Considerations

A review of the basics of zoning in general may be helpful before considering issues specific to zoning for solar. Zoning is a common tool that local governments use to regulate land development. A zoning ordinance (sometimes called a land use ordinance or unified development ordinance (UDO)) defines a variety of zoning districts and delineates where those districts apply. Common zoning districts include agricultural, residential, commercial, office, and industrial. Districts may be further differentiated based on density and intensity of the particular uses.

For each zoning district, the zoning ordinance provides use restrictions and dimensional development standards. Use restrictions specify what types of uses are permitted in the district. Within the use districts, particular uses may be permitted, permitted by conditional or special use permit, or prohibited. Dimensional standards are those such as height limits, lot coverage, and setbacks from property lines. As an example, in a residential zoning district the uses may be limited to low-density single-family homes and comparable uses, and buildings may be limited to 30 feet tall and a setback of 20 feet from the property lines. Each local government establishes its own districts and standards. Many local governments now are permitting a mix of uses in zoning districts and accommodating large-scale projects that do not fit neatly into the common use categories. The emphasis is on the forms and types of buildings, with use being a secondary consideration.

In many ways solar is just another type of development. It may be permitted in certain districts, prohibited in others, and permitted conditionally in still others. Dimensional standards generally apply and other standards such as vegetative buffering may be appropriate. Just as with the development of a new office building, shopping center, or residential neighborhood, communities must make determinations about where solar development is appropriate, what standards are necessary, and what review process is desired.

Some questions a community should consider in amending its zoning ordinance for solar energy systems include the following:

- How should solar development be defined and distinguished?
- Where is solar appropriate?
- What should the standards for principal solar uses be?
- What should the standards for accessory solar uses be?
- How can solar be balanced with competing interests in the ordinance?

The answers to these questions depend on the land use impacts of solar development and the policy decisions of individual jurisdictions. The sections below first outline the possible land use impacts of different scales of solar development. Subsequent sections analyze how some local governments have answered the preceding questions.

Solar farms, such as this one in Beaufort County, can have significant visual impacts, particularly without any setback or buffering requirements.

Potential Land Use Impacts

Aesthetics

As with all land uses, the land use impact of a solar project depends on its size, location, and context. The primary land use impact of solar energy systems is aesthetic. A panel installed as an awning may have only minimal visual impact. Meanwhile, a large array in an open field next to an existing residential neighborhood may create a substantial visual impact. Several factors affect the aesthetic impact of a solar energy system. Size, height, and configuration are obvious factors. A related aspect is exposure to public view (is it visible from the public right-of-way?). These factors may be critical when identifying appropriate districts, crafting appropriate standards, and considering mitigating conditions.

Comparing the aesthetic impacts of solar projects to other similar visual impacts can be helpful in assessing the potential aesthetic effects of new solar development. For flat roofs, solar panels may have a visual impact similar to that of the HVAC and other equipment that commonly clutter commercial roofs. For pitched roofs, flush-mounted rooftop solar panels may have a visual impact comparable to skylights.

Noise

Compared to many land uses, solar farms are very quiet. They are not silent, however. The inverters—equipment that converts the DC current from the solar panels into AC current for the electric grid—produce an audible hum or whirr. Separately, the associated transformers may produce a hum, and the mechanical components used for tracking solar panel systems may also create low-level, intermittent noise.

The sound levels of the inverters are modest—not unlike an air conditioner or similar appliance—and the inverters may be installed at interior locations within the array. A Massachusetts study examined the sound levels near three different solar farms. It found that "[s]ound levels along the

The pitch and size of accessory solar panels can create visual impacts, even on a flat roof.

Inverters—the equipment needed to convert the current from DC to AC—create a minor amount of noise.

fenced boundary of the PV [photovoltaic] arrays were generally at background levels, though a faint inverter hum could be heard at some locations. Any sound from the PV array and equipment was inaudible at set back distances of 50 to 150 feet from the boundary."[1]

Stormwater

The stormwater impacts of a solar installation will depend upon the project, but generally panels are not included in the calculation of impervious surface for stormwater purposes. A fixed-mount solar farm may be installed with minimal impact to the topography, maintained with natural soil and groundcover underneath, and arranged with reasonable distance between the arrays to allow any runoff to naturally infiltrate and drain. However, a solar installation could be arranged in a manner that collects and channels stormwater runoff, depending on panel spacing and configuration. In that case, the panels may be treated as impervious surface. Additionally, a solar development site stripped of vegetation and soils may result in erosive stormwater flows. Qualified professionals can advise on appropriate stormwater management for construction and post-construction phases.

Elements of a solar farm that alter the natural infiltration, such as steel poles driven into the ground and any other racking components on the ground, will always be treated as impervious. Other impervious elements would include concrete pads or foundations for racks or inverter cabinets. Solar installed on a rooftop, parking lot, or other established impervious surface will not alter the existing area and it would remain impervious.

1. Peter H. Guldberg, "Study of Acoustic and EMF Levels from Solar Photovoltaic Projects," pt. 3, Massachusetts Clean Energy Center, Dec. 17, 2012, www.masscec.com.

Although glare is generally not an issue, in certain cases it may be a concern for nearby highway traffic, air traffic, or neighbors.

Glare

Glare is one commonly cited concern regarding solar energy systems. Fortunately the design and siting of a project can reduce or eliminate any glare issues. Textured glass and anti-reflective coatings produce less intense glare than smooth glass or mirrors. Solar energy systems are designed to absorb solar energy and typically are angled up, so most glare will be directed upward. That said, typical PV technology still relies on relatively smooth glass, which can create a strong reflection, especially in the morning and evening when the angle of the sun is low.[2]

Significant glare can pose a hazard for air travel and, in some cases, motorists and neighbors. A PV array atop a parking garage at the Manchester–Boston Regional Airport had to be covered to eliminate glare to the air traffic control tower. The Federal Aviation Administration now requires a glare analysis for solar installations near airports.[3] Comparable concerns may arise in proximity to military installations. The U.S. Department of Energy's Sandia National Laboratories has released a web-based Solar Glare Hazard Analysis Tool available to the public to analyze glare impacts of a potential solar energy system.[4]

Safety

Opponents of solar projects occasionally claim that PV panels, especially the materials within the panels, are unsafe. The actual concern is limited. The typical PV panel is constructed mostly of glass and aluminum. Panel semi-conductors—the components that convert sunlight to electricity—are usually made of crystalline silicon and only account for a small percentage of the panel weight. Silicon is a common element found in sand and used in glass, bricks, and household

2. Stephen Barrett, "Glare Factor: Solar Installations and Airports," *Solar Industry*, June 2013, http://solarindustrymag.com.

3. Clifford K. Ho, "Relieving a Glaring Problem," *Solar Today*, April 2013, https://share.sandia.gov/phlux/static/references/glint-glare/Ho-SolarToday-April13_v2.pdf.

4. Solar Glare Hazard Analysis Tool (SGHAT), Sandia National Laboratories, https://share.sandia.gov/phlux.

electronics. A small amount of lead may be used in the electrical solder in the modules. PV panels using cadmium are more popular in desert climates, and moreover, the cadmium in one module is comparable to that in a C-size rechargeable battery. Regardless of the materials, they are contained in a solid matrix, so they are insoluble and non-volatile under normal conditions. Releases to the ground or air are unlikely.[5] At the end of a PV panel's useful life, most of the panel may be recycled.[6]

Research indicates that electric field levels are not concerns for solar energy systems. A study of Massachusetts solar farms concluded that "[a]t the utility scale sites, electric field levels along the fenced PV array boundary, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels (< 5 V/m)."[7] Neither are magnetic field levels generally a concern. That same Massachusetts study found that magnetic fields are very low at the fenced boundary of a solar farm and drop to background levels at 50–150 feet from the fenced boundary. Higher magnetic field levels are present within a few feet of utility-scale inverters, but those levels drop to very low or background levels at 150 feet.

Two distinct issues of fire safety may arise with regard to solar development: (1) risk of fire from solar panels and (2) firefighter safety, including roof access and risks of shock. These issues generally are handled through product standards as well as building and electric code requirements, not land use zoning. Even so, these safety considerations deserve some mention. On April 16, 2011, a pair of faults in the wiring of a rooftop PV system in Mount Holly, North Carolina, resulted in a rooftop fire. Solar experts have proposed technical and design fixes to avoid such faults in the future.[8] Section 605.11 of the 2012 International Fire Code provides information on PV installation and fire safety, including marking, locations for wiring and conductors, roof access, and ground-mounted PVs.[9] (North Carolina has not yet adopted the 2012 version of the International Building Codes.) Underwriters Laboratory (UL) and the North Carolina Office of the State Fire Marshal each offer online training concerning PV systems and fire safety.[10]

Operations

Traffic is a common land use concern. In the case of solar, however, traffic is a minor issue. Solar farms require limited maintenance, so traffic levels after the initial construction phase are minimal.

---

5. "Clean Energy Results, Questions and Answers: Ground-Mounted Solar Photovoltaic Systems," Massachusetts Department of Energy Resources, Massachusetts Department of Environmental Protection, and Massachusetts Clean Energy Center, Dec. 2012, www.mass.gov.

6. Debbie Sniderman, "Life After Death," Solar Builder, May 14, 2012, www.solarbuildermag.com.

7. Peter H. Guldberg, "Study of Acoustic and EMF Levels from Solar Photovoltaic Projects," Massachusetts Clean Energy Center, Dec. 17, 2012, iv, www.masscec.com.

8. "Ground-Fault Detection Blind Spot," Solar America Board for Codes and Standards, www.solarabcs.org.

9. 2012 International Fire Code, International Code Council, May 2011, http://publicecodes.cyberregs.com.

10. "Firefighter Safety and PV Course," Underwriters Laboratory, http://lms.ulknowledgeservices.com; "Pocket Tools Training: Student Review," North Carolina Office of State Fire Marshal, www.ncdoi.com/OSFM.

The majority of the required maintenance is for the ground cover. Depending on the site and design, a solar farm may require occasional mowing. Some solar operators use sheep to graze the grass between solar arrays.

Property Value

Research indicates that accessory solar on residential properties may in fact raise property value. Research prepared for the U.S. Department of Energy and the National Renewable Energy Laboratory analyzing California home sales prices between 2000 and 2009 found a premium paid for homes with PV systems over comparable homes without PV systems.[11]

The more critical question for land use ordinances, though, is how does a solar development affect neighboring property values? As discussed below, quasi-judicial permits usually require that new development not injure neighboring property values. As with quasi-judicial proceedings for any other type of development, opinion testimony concerning impacts to property value must be provided by a qualified expert (such as an appraiser) and supported by relevant facts.[12] Indeed, the standard of property value is a critical point of debate in many quasi-judicial decisions, and the adequacy of evidence concerning that standard commonly is the subject of judicial appeals.

Given the rapid rise of the solar industry in North Carolina and the lingering effects of the recent recession, as of this writing data on the effects of solar farms on neighboring property values in North Carolina is limited. There may be few, if any, comparable sales by which to gauge any impact on property values. In a conditional use permit application hearing for a solar farm in Laurinburg,[13] the applicant offered evidence from a certified general appraiser, including sworn testimony and a sworn affidavit of the appraiser's findings. The appraiser's research did not identify any comparables, so the appraiser considered whether the solar farm would have any negative impacts that might decrease property value, such as appearance, traffic, odor, noise, or hazardous materials. In the appraiser's opinion, the solar farm would not injure neighboring property values.

Of course, different appraisers may hold different opinions, and opponents to a solar farm may present their own expert testimony concerning property values. Additionally, as the solar industry matures, more reliable data on the effects of solar farms on property values may become available.

Defining and Distinguishing Solar

The first question concerning zoning for solar is simple: What is solar? How is it defined? Some communities have concluded that the existing zoning ordinance categories or definitions can accommodate solar projects. Defined uses for utilities or institutional infrastructure may be broad enough to include utility- or commercial-scale solar energy systems. However, the land use impacts of solar may be substantially different from uses that typically qualify in those categories.

11. Ben Hoen, Ryan Wiser, Peter Cappers, and Mark Thayer, "An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California," LBNL-4476E, Environmental Energy Technologies Division, Earnest Orlando Lawrence Berkeley National Laboratory, April 2011, http://emp.lbl.gov.

12. N.C. Gen. Stat. (hereinafter G.S.) § 160A-393(k)(3), www.ncleg.net.

13. "Council Meeting Minutes," City of Laurinburg, N.C., Apr. 16, 2013, Min. Bk. 17, 77–104, www.laurinburg.org.

Some jurisdictions have adopted ordinances covering several alternative energy technologies (such as solar, wind, and biogas).[14] Given the notable differences in the technologies and land use impacts, however, such an approach is challenging at best. Large-scale wind turbines are more akin to telecommunication towers than to solar farms. Often a newly defined use (or uses) is needed to properly handle solar energy systems in the zoning ordinance. Given the variety of solar projects, categorizing and distinguishing them are necessary.

Important Distinctions

Accessory v. Principal

The major distinction for solar uses involves scale and context: Is it an accessory solar use or a principal solar use? This is a valid and important distinction but can be challenging to make. The residential rooftop system is obviously accessory and the 200-acre solar farm is obviously principal. The many gradations in between make setting clear definitions for what is accessory critical. Common standards call for the accessory use to be incidental to the principal use.

Roof-Mounted v. Ground-Mounted

Roof-mounted and ground-mounted systems have different characteristics and deserve separate treatment. Height, setbacks, sizing and lot coverage, angles, and aesthetics will differ depending on whether a solar energy system is roof- or ground-mounted. Often the distinction between accessory and principal aligns with the distinction between roof- and ground-mounted. But that is not always the case. Building-integrated solar, those systems installed as part of the building (an awning, window, and so forth) may be treated distinctly or simply regulated the same as the building component.

Less Important Distinctions

Thermal v. Photovoltaic

The technology for a solar thermal system is completely different from a solar PV system, but the land use impact is virtually the same—the solar panels are dark panels that may be installed on the roof or ground to produce energy on-site with little noise or traffic. Many communities find it beneficial to treat thermal and PV the same under their ordinances.

Energy Consumption and Grid Connection

There are many different models for the ownership and operation of a solar project, as well as for the purchase and consumption of the energy produced. Ultimately, however, those financial and contractual matters do not affect the land use impacts of a solar energy system. A solar panel on a residential rooftop has the same impact (visual and otherwise) whether it is producing energy that is consumed on-site, sold to the grid, or charging a battery in the attic. Similarly, a 200-acre solar farm has the same land use impacts regardless of whether the energy flows into a nearby electric utility line or is consumed by an on-site manufacturing facility. Thus, from a land use perspective there may be no meaningful distinction between whether energy is consumed on-site or fed into the electric grid.

---

14. A Model Ordinance for Energy Projects, Version 2, Oregon Department of Energy, July 2005, www.oregon.gov.

Districts and Approval Procedure

When a local government considers appropriate uses for a zoning district, it is generally concerned with compatibility. In other words, what uses play well together? In a low-density residential district, for example, forestry and some low-impact agricultural operations may be allowed, as well as some home occupations with limited traffic and noise. Typical accessory uses and structures (such as garages) also are permitted. Large-scale commercial uses and noisy industrial uses would not be compatible in such neighborhoods.

The analysis is no different for solar uses. Where is solar compatible? First, consider solar accessory uses. Like other accessory uses, accessory solar typically is permitted in all districts. It is treated similarly to HVAC equipment or small accessory structures. Particular dimensional standards for accessory solar (roof-mounted and ground-mounted) are discussed in more detail in "Standards for Solar as an Accessory Use" (below). Some jurisdictions merely require a basic zoning permit, but others call for specific site plan review. For accessory solar systems, the Town of Navassa requires site plans and elevation drawings to depict the building, the solar equipment, and the property lines. Such plans are administratively approved if they meet the applicable development standards.[15] The N.C. Template Solar Ordinance allows roof-mounted, small ground-mounted, and parking lot canopy solar (all essentially accessory uses) as by-right uses.[16]

For solar farms, where solar is the principal use, compatibility is the key. So what does solar resemble? It generates electricity, but it is not industrial like a power plant. It is generally quiet, but has more visual impact than a pasture. It involves a substantial investment in a property, but it does not have the same noise and traffic impacts of a shopping center. As discussed in "Potential Land Use Impacts" (above), after the initial construction phase, solar development typically is quiet, it generates very little traffic, and the stormwater impacts are generally modest. The height is less than for most buildings that could be built on the site, although lot coverage may be greater than a typical low-density development. The visual impacts will depend upon the site and project configuration.

To balance these potential land use impacts, many communities permit solar farms in industrial districts and rural agricultural districts.[17] Additionally, jurisdictions commonly permit some amount of principal solar use in commercial and residential districts.

Permitting procedures may, of course, be adjusted to increase or decrease the level of review for solar projects. Consider the following procedural requirements for by-right development (basic approval; limited process) and quasi-judicial review (discretionary approval; additional process).

- ***By-right***. When solar development is permitted by-right, the applicant must show only that the project meets the basic administrative standards (setback, height, and so forth) and any additional development standards. Such application may require a basic zoning permit; in some cases a site plan may be required as well.[18] The Minnesota Model Ordinance calls for

---

15. Town of Navassa Zoning Ordinance § 8.2(5), www.townofnavassa.org.

16. Template Solar Energy Development Ordinance for North Carolina, Table 1, North Carolina Sustainable Energy Association and North Carolina Solar Center, Dec. 2013, http://energync.org.

17. The City of Archdale permits solar farms by special use permit in low-density rural agricultural districts and manufacturing districts. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov. In Asheboro, solar farms are permitted in the industrial district and as a special use in the low-density residential district. Asheboro, N.C., Zoning Ordinance §§ 328A & 652, www.ci.asheboro.nc.us.

18. Saint Pauls requires a site plan to show panel configuration and ordinance compliance. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.

administrative plan approval for accessory solar, including horizontal site plan and vertical (elevation) drawings, with distinct requirements for pitched roofs and flat roofs.[19] For all by-right uses, if the project meets the basic standards, the applicant has a right to develop the project. No project-specific conditions may be applied. Because of the clear standards and staff review, processing approval of by-right uses is more predictable and timely.

- ***Quasi-judicial review***. In some cases, jurisdictions require a conditional use permit or special use permit before a project may proceed. Conditional use and special use permits typically require that the applicant show that the project meets certain discretionary standards. The decision-making board holds a quasi-judicial hearing to make findings of fact as to whether the project meets the stated standards. The applicant and any opponents must provide substantial, competent, and relevant evidence (including sworn testimony) to support their cases. Common standards require that the project does not injure neighboring property values, does not harm public health and safety, is in harmony with the area, and conforms with adopted plans.[20] Reasonable conditions may be applied to quasi-judicial approvals to bring the project into compliance with ordinance standards. Because quasi-judicial approvals involve discretionary standards and must be approved by a decision-making board, they are less predictable and more time-consuming than approvals permitted by right.

The N.C. Template Solar Ordinance provides an example of how these different types of review can be used. It allows mid- to large-scale solar uses in all districts, with different review standards for different use districts (administratively reviewed development standards for some and special use permits for others).[21]

Standards for Solar as a Principal Use

This section reviews and evaluates standards commonly applied to solar farms. These standards concern height and setbacks, screening and fencing, design and operations, size, and decommissioning. Local governments make different decisions about these standards, but similar factors are considered in the policy-making process.

19. For pitched roofs, the elevation must show the highest finished slope of the roof and the solar collector. For flat roofs, the drawing must show any parapets, the height of the building's street frontage side, the distance between the solar energy system and the street frontage edge of the building, and the height of the solar collector. Brian Ross, "Solar Energy Standards, from Policy to Reality: Updated Model Ordinances for Sustainable Development," § IV.E., Minnesota Pollution Control Agency, Apr. 2013, www.crplanning.com.

20. David W. Owens, "Special Use Permits in North Carolina Zoning," UNC School of Government, *Special Series* No. 22, Apr. 2007, www.sog.unc.edu.

21. Template Solar Energy Development Ordinance for North Carolina, Table 1, North Carolina Sustainable Energy Association and North Carolina Solar Center, Dec. 2013, http://energync.org.

Height and Setbacks

Height for solar farms is commonly limited to 25 feet.[22] Some jurisdictions set height limits as low as 8 feet.[23] Perquimans County falls in the middle. Its height limit is 15 feet.[24] Fifteen or 20 feet likely is sufficient for typical solar arrays.

Setback requirements are commonly tied to the standard setbacks for the zoning district.[25] Some jurisdictions add a setback minimum (for example, 20 or 25 feet) so that the solar development must meet it or the district setback, whichever is greater.[26] Some jurisdictions apply substantially greater setback requirements. Archdale requires a 100-foot setback.[27] And still other jurisdictions apply an increased setback for solar equipment from residences. Pleasant Garden and the N.C. Template Ordinance each require a setback of 100 feet from any residential structure.[28]

Requirements for setbacks and restrictions on height may need to take into account accessory equipment such as inverters and electric poles.

---

22. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov; Zoning Ordinance, Davidson County, North Carolina § 5.08(GG), www.co.davidson.nc.us; Town of Navassa Zoning Ordinance § 9.2(36), www.townofnavassa.org.

23. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org; Fairview, North Carolina, Land Use Ordinance § 180P, http://fairviewnc.gov.

24. Ordinance No. 88, Zoning Ordinance, Perquimans County § 907.28(B.), www.co.perquimans.nc.us.

25. Asheboro, N.C., Zoning Ordinance § 328A, www.ci.asheboro.nc.us.

26. Town of Navassa Zoning Ordinance § 9.2(36), www.townofnavassa.org; Fairview, North Carolina, Land Use Ordinance § 180P, http://fairviewnc.gov.

27. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov.

28. Development Ordinance, Town of Pleasant Garden, North Carolina § 6-4.69, http://library.municode.com/index.aspx?clientId=14932; see also Template Solar Energy Development Ordinance for North Carolina, Table 2, North Carolina Sustainable Energy Association and North Carolina Solar Center, Dec. 2013, http://energync.org.

Screening and buffering requirements may be appropriate to shield nearby residences or the public right-of-way. Complete perimeter buffering, however, may be excessive.

Screening and Fencing

The requirements for screening and fencing vary greatly. Some jurisdictions leave this matter to the owner's discretion, some require some sort of barrier, and others address the issue through the terms of conditional and special use permits.

Fencing may be needed to address some safety concerns, as a solar farm is a valuable, unmanned development. The panels may be a curiosity to bored teenagers and an easy target for unscrupulous salvagers. Regardless of any local requirements, many solar developers install fencing to protect their substantial investment in solar equipment and meet electric code requirements that wiring be not easily accessible. Still, some jurisdictions do impose specific fence requirements. Saint Pauls calls for a 6-foot fence for the site and an 8-foot fence for the inverter and mechanical equipment.[29]

Screening and buffering can be useful tools for mitigating specific visual impacts (such as for neighboring residences), but planting evergreens around the entire perimeter of a site is often unnecessary and overly burdensome. Some jurisdictions try to find a middle ground for screening. Davidson County requires solar farms to be screened from routine view from public rights-of-way and residentially zoned property.[30] Saint Pauls requires an evergreen buffer between solar farms and abutting residential property.[31]

Shade is another consideration for screening. Any vegetative buffering requirement should recognize that tall vegetation will negatively impact the solar farm. Archdale requires that solar farms be fully screened from neighboring properties and roads, but the ordinance notes that

29. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.
30. Zoning Ordinance, Davidson County, North Carolina, § 5.08(GG), www.co.davidson.nc.us.
31. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.

shading should be avoided.[32] In addition to screening requirements, Archdale specifies that solar farms must not interfere with certain views and from sites of public interest (scenic roads and historic resources).[33]

Design and Operations

Local jurisdictions have imposed a variety of design and operational standards for solar farms. Glare, safety codes, and parking are among the issues addressed by some solar ordinances.

As noted in the discussion of potential solar land use impacts, in certain circumstances glare may be an issue for solar development, but it can be alleviated with proper design and mitigated with screening. The level of concern over glare will vary depending on the nearby land and land uses. Glare may be a greater issue in hilly terrain than on flat coastal plains. Additionally, proximity to an airport or other air operations may increase safety impacts of glare. Huntersville requires that glare-resistant panels be used for solar facilities near the local airport.[34] Saint Pauls requires an engineer to confirm that glare will not offend residences or traffic.[35] Currituck County calls for solar farms to be configured to avoid glare and heat transference to adjacent lands.[36] As mentioned above, the web-based Solar Glare Hazard Analysis Tool is available to the public to analyze glare impacts of a potential solar energy system.[37] The N.C. Template Solar Ordinance mandates that developers planning a solar facility larger than .5 acre must evaluate the project using the glare analysis tool and provide notice of the project and a copy of the glare analysis to nearby airport operators and military posts.[38]

Some jurisdictions specify additional safety standards. Navassa, for example, requires that solar equipment have proper UL listing and that the installation comply with the building code (including hurricane-force wind velocity requirements) and the National Electric Code.[39] Brunswick County similarly calls for UL-listed components and building code compliance (including an up to 130 mph wind load capacity).[40] Some such standards may be unnecessary, as they merely restate standards with which the development must already comply.

Wiring and noise levels are other specific issues that may be addressed by a solar ordinance. Jurisdictions may require that solar component wiring be placed in underground trenches.[41] Saint Pauls sets a maximum decibel level for inverter noise (40 dBA at the property line).[42]

---

32. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov; Zoning Ordinance, Davidson County, North Carolina § 5.08(GG), www.co.davidson.nc.us.

33. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov; Zoning Ordinance, Davidson County, North Carolina § 5.08(GG), www.co.davidson.nc.us.

34. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.

35. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.

36. Currituck County Unified Development Ordinance § 4.2.3.H.I, www.co.currituck.nc.us.

37. Solar Glare Hazard Analysis Tool (SGHAT), Sandia National Laboratories, https://share.sandia.gov/phlux.

38. Template Solar Energy Development Ordinance for North Carolina § 7, North Carolina Sustainable Energy Association and North Carolina Solar Center, Dec. 2013, http://energync.org.

39. Town of Navassa Zoning Ordinance § 9.2(36), www.townofnavassa.org.

40. Brunswick County, North Carolina, Unified Development Ordinance § 5.3.4.P, www.brunsco.net.

41. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV), www.archdale-nc.gov.

42. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.

Solar farms generate very little traffic and have limited need for parking. Huntersville specifically states that solar farms are exempt from parking standards if there is no associated commercial or office building.[43] Currituck County has no minimum parking standards for solar farms. [44]

Size

Some jurisdictions set a minimum size for solar farms. Huntersville sets a minimum of 10 acres for major solar facilities,[45] Davidson County requires a minimum of 5 acres,[46] and Fairview requires a minimum 2-acre lot for a solar farm.[47] Alternatively, jurisdictions may use size thresholds to differentiate types of projects and approvals. The N.C. Template Solar Ordinance, for example, provides different approval procedures based on certain acreage thresholds.[48]

Decommissioning

What will happen when the solar farm is no longer a solar farm? Communities take very different approaches to decommissioning. Some ordinances make no mention of end-of-operation concerns. Several communities state a basic requirement that solar structures be removed after some period (commonly twelve months) of inactivity.[49]

Other communities require some planning or funding to better ensure that decommissioning will be complete. In Huntersville, the special use permit process requires that the town get a copy of the lease and the plan for decommissioning.[50] Saint Pauls requires a decommissioning plan to be filed with the city to specify how the site will be returned to an agricultural or natural state.[51] Iredell County requires a decommissioning plan that identifies the responsible party, estimates costs of decommissioning, and states the method of ensuring funds will be available.[52]

Decommissioning bond requirements commonly accompany permitting for towers (telecommunication, wind turbine, and others). Of course, for towers there are significant public safety concerns for a poorly maintained structure and significant costs for decommissioning. Solar farms do not raise the same safety concerns as towers. Many communities leave it to property owners and solar developers to make private arrangements for financing decommissioning. A few communities, however, require decommissioning bonds to protect against potential problems in the future. Pasquotank County requires a bond or irrevocable letter of credit in favor of the county to cover the estimated cost of decommissioning a solar farm.[53]

43. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.
44. Currituck County Unified Development Ordinance Table 5.1.3.C, www.co.currituck.nc.us.
45. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.
46. Zoning Ordinance, Davidson County, North Carolina, § 5.08(GG), www.co.davidson.nc.us.
47. Fairview, North Carolina, Land Use Ordinance § 180P, http://fairviewnc.gov.
48. Template Solar Energy Development Ordinance for North Carolina § 2, North Carolina Sustainable Energy Association and North Carolina Solar Center, Dec. 2013, http://energync.org.
49. Iredell County Land Development Code § 3.1, R65, www.co.iredell.nc.us; Archdale, N.C., Zoning Ordinance § 6.5, SR 41(IV.8), www.archdale-nc.gov.
50. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.
51. Town of St. Pauls, N.C., Zoning Ordinances § 2.67, www.stpaulsnc.gov.
52. Iredell County Land Development Code § 3.1, R65, www.co.iredell.nc.us.
53. Zoning Ordinance of the County of Pasquotank, North Carolina, § 9.04-29.f, www.co.pasquotank.nc.us.

Standards for Solar as an Accessory Use

Solar energy systems that are accessory to a principal use are, in many ways, no different than any other accessory use. They are reasonable and logical uses related to principal uses. That said, there are some special considerations for solar, as compared to a garage or home occupation. Is it roof-mounted or ground-mounted? How do the height and setback regulations apply? What distinctions matter and what issues can be set aside?

Sections 153A-144 and 160A-201 of the North Carolina General Statutes limit local regulation of solar development that is accessory to residential structures. Under the statutes, local ordinances may not prohibit (directly or indirectly) solar accessory to residential uses, but local ordinances still may require screening and restrict location. Common restrictions for residential solar installations include setbacks, screening, maximum height, and yard placement. Ordinances can prohibit solar on the front façade or in the front yard of residences.

Some jurisdictions treat accessory solar as one big category, applying the same basic standards to all accessory solar. Others have careful distinctions among different types of accessory solar. This section outlines some of the separate considerations for roof-mounted accessory solar and ground-mounted accessory solar.

Visibility

Whether the solar installation is ground- or roof-mounted, visibility is a central issue for accessory solar uses. Navassa calls for accessory solar development to blend into the architecture of the building or be screened from public view.[54] Brunswick and Davidson counties also require screening from public rights-of-way or residential properties.[55]

Flush-mounted rooftop solar may have a minor visual impact.

---

54. Town of Navassa Zoning Ordinance § 8.2(5), www.townofnavassa.org.

55. Brunswick County, North Carolina, Unified Development Ordinance § 6.10.1.A.5, www.brunsco.net; Zoning Ordinance, Davidson County, North Carolina, § 6.02(G), www.co.davidson.nc.us.

Some ordinances differentiate among solar installations in complex ways based on visibility. Huntersville, for example, prohibits solar in the front yard, requires a special use permit for solar on a residence's front façade or front-facing roof slope, and allows solar by right in side and backyards.[56] In commercial districts Huntersville permits solar by right for flat roofs and side-facing sloped roofs; a special use permit is required for commercial accessory solar that is ground-mounted or roof-mounted on a sloped roof facing the public right-of-way.[57]

The Archdale ordinance calls for the solar energy system to mitigate glare and be directed away from neighboring property or roads if a nuisance or safety hazard may be created.[58]

Roof-Mounted Accessory Solar

In regulating roof-mounted solar energy systems, communities must consider visibility, distinctions between sloped roofs and flat roofs, and the relation to general height requirements. Even communities that restrict solar visible from the public right-of-way recognize that solar on flat roofs or rear-facing sloped roofs has no substantial visual impact. In most cases, solar is permitted by right on such roofs.

Height

How do you measure and restrict height for a roof-mounted solar panel? Should the height be based on district height limits or on some distance from the roof? Maybe both. Some jurisdictions simply tie the solar height limit to the district height limits.[59] So, if the district height maximum is 30 feet, then the roof-mounted solar could be as tall as 30 feet. But zoning in this manner creates two peculiar situations. First, consider a 15-foot-tall flat-roofed building. Solar panels could be substantially taller than the roof plane, creating notable visual impacts as compared to a flush-mounted solar array.[60] Next, consider the neighboring property built to the maximum height of 30 feet. This neighbor could not install any roof-mounted accessory solar if it exceeded the 30-foot limit.

Two points of flexibility may address this situation. First, to prevent installation of solar panels towering over buildings, the height limit for solar may be tied to the roof plane. In Archdale, for example, roof-mounted solar must comply with the height limits of a zone, but these solar installations can be no taller than the peak of a sloped roof and no higher than 5 feet above a flat roof.[61] Second, in order to allow solar on existing buildings that meet or exceed height limits, the ordinance may provide some allowance for rooftop solar to extend beyond standard height limits. The Minnesota Model Ordinance calls for roof-mounted accessory solar to meet the maximum height for the district but allows the height exception for roof-mounted mechanical equipment to apply to solar.[62] In Currituck County if the building already exceeds the height limit, then the

---

56. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.

57. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.

58. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(III), www.archdale-nc.gov.

59. Zoning Ordinance, Davidson County, North Carolina, § 6.02(G), www.co.davidson.nc.us.

60. Allowing solar panels 15 feet above a roof plane is a policy decision for local governments, and some jurisdictions do authorize such solar installations. Currituck County allows roof-mounted accessory solar to be up to 15 feet above the roofline, provided the system is still within the district height limits. Currituck County Unified Development Ordinance § 4.3.3.V, www.co.currituck.nc.us.

61. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(III), www.archdale-nc.gov.

62. Brian Ross, "Solar Energy Standards, from Policy to Reality: Updated Model Ordinances for Sustainable Development," § IV, Minnesota Pollution Control Agency, Apr. 2013, www.crplanning.com.

solar array may extend 5 feet beyond the roofline.[63] Raleigh's UDO provides that solar panels "may exceed the established height limits . . . provided they do not exceed the maximum building height by more than 12 feet."[64]

To minimize visual impacts, local regulations may require that solar panels on sloped roofs be flush-mounted (close and parallel to the roof plane). In those cases, the plane of the solar panel may be 1 foot or less from the plane of the roof.

Additional height allowance is necessary to provide for an appropriate angle for solar panels on flat roofs. Height limits may still be related to the roof plane but should be greater than those for flush-mounted panels.

Setbacks

Setbacks are not a critical concern for roof-mounted systems since they are limited to the roof. That said, as an appropriate precaution a local ordinance should specify that roof-mounted solar is limited to the area within the roof perimeter.[65] Also, an ordinance may require solar on flat roofs to be set back from the perimeter to minimize or avoid visibility from the public. Ordinances may call for roof-mounted solar to preserve safe roof access.[66]

Ground-Mounted Accessory Solar

Ground-mounted accessory solar raises different issues of siting, setbacks, and height. In many respects ground-mounted accessory solar should simply be treated as any other accessory structure. What are the height limits for garages? What are the setbacks? These restrictions may appropriately apply to solar. As with other accessory structures, the policy considerations will depend upon context.

Height

Some jurisdictions limit ground-mounted accessory solar to 5 or 6 feet in height.[67] Others permit arrays as tall as 20 or 25 feet.[68] In a large-lot rural residential development, 20-foot-tall, ground-mounted accessory solar arrays may be perfectly acceptable. The same tall array in an in-town small-lot development could cast shadows and potentially fall onto neighboring property. On the other hand, a 5-foot height limit may be overly restrictive, particularly as compared to potential heights for a backyard shed, garage, or pergola. In the case of solar canopies, additional height likely is necessary.

---

63. Currituck County Unified Development Ordinance § 4.3.3.V, www.co.currituck.nc.us.

64. Raleigh, N.C., Unified Development Ordinance § 1.5.7.D.2, www.raleighnc.gov.

65. Brunswick County, North Carolina, Unified Development Ordinance § 5.4.10, www.brunsco.net.

66. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(III), www.archdale-nc.gov; Brian Ross, "Solar Energy Standards, from Policy to Reality: Updated Model Ordinances for Sustainable Development," § IV, Minnesota Pollution Control Agency, Apr. 2013, www.crplanning.com.

67. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org; Brunswick County, North Carolina, Unified Development Ordinance § 5.4.10, www.brunsco.net.

68. Town of Navassa Zoning Ordinance § 8.2(5), www.townofnavassa.org; Zoning Ordinance, Davidson County, North Carolina, § 6.02(G), www.co.davidson.nc.us; Brian Ross, "Solar Energy Standards, from Policy to Reality: Updated Model Ordinances for Sustainable Development" § IV, Minnesota Pollution Control Agency, Apr. 2013, www.crplanning.com.

The issues and concerns for ground-mounted accessory solar are distinct from those of roof-mounted solar.

Setbacks and Yards

As with height, general district standards for accessory structure setbacks may be appropriate for ground-mounted accessory solar.[69] In Huntersville, accessory solar must comply with the standard setbacks and spacing for accessory structures.[70] In Archdale, solar must comply with the setbacks and be no closer than 10 feet from the rear or side property line.[71] In residential districts, many communities choose to limit or prohibit solar panels in the front yard.[72]

Setbacks also may warrant flexibility. Raleigh's UDO provides that "[s]olar panels or wind turbines may extend into a required rear or side setback, provided that such extension is at least 3 feet from the vertical plane of any lot line."[73]

Area/Coverage

Jurisdictions have used various methods to limit the amount of area that may be used for ground-mounted accessory solar. Some ordinances set a simple cap on the size of a solar energy system (400 square feet, for example).[74] Such a cap, though, could apply regardless of whether the solar was accessory to a small residence, an apartment complex, or a large warehouse. Alternatively, jurisdictions may set a proportional size limit based on lot or principal structure size. Pleasant Garden limits the area of ground-mounted solar in residential districts to 25 percent of the primary residence's heated square feet.[75] Currituck County limits accessory solar to the greater of 600 square feet or one-half of the footprint of the principal structure.[76] Some jurisdictions do not set a size limit.

---

69. Brian Ross, "Solar Energy Standards, from Policy to Reality: Updated Model Ordinances for Sustainable Development" § IV, Minnesota Pollution Control Agency, Apr. 2013, www.crplanning.com.

70. Huntersville, N.C., Interactive Zoning Ordinance § 9.54, www.huntersville.org.

71. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(III), www.archdale-nc.gov.

72. Archdale, N.C., Zoning Ordinance § 6.5, SR 41(III), www.archdale-nc.gov.

73. Raleigh, N.C., Unified Development Ordinance § 1.5.4.D.2., www.raleighnc.gov

74. Zoning Ordinance, Davidson County, North Carolina, § 6.02(G), www.co.davidson.nc.us.

75. Development Ordinance, Town of Pleasant Garden, North Carolina, § 6-4.69, http://library.municode.com/index.aspx?clientId=14932.

76. Currituck County Unified Development Ordinance § 4.3.3.V, www.co.currituck.nc.us.

The height and location characteristics of solar canopies are distinct from those of other accessory solar uses.

Is it Accessory?

As the solar industry evolves and new technologies gain marketability, interesting questions concerning accessory use arise. First, consider building-integrated solar—solar shingles, solar awnings, and solar film on windows. While some communities do apply restrictions and permitting to such solar installations, others choose to treat them the same as the underlying building component. How would an awning be permitted, for example? A solar awning would be permitted the same way. (Appropriate electrical code permitting would still apply to the solar awning.)

Another interesting question for determining accessory use and related regulations arises in the context of the solar canopy over a driveway or parking lot. This type of solar development has many advantages: it is built upon an already impervious surface, it creates a dual use for developed land (parking and energy creation), and it could double as a charging station for electric cars. That said, solar canopies must be taller than other ground-mounted systems in order to have room to park underneath. In addition, the 20-foot-tall canopy will visually impact neighbors much more than a flat parking lot. Thus, solar canopies may deserve consideration beyond that typically given to common ground-mounted accessory uses.

Competing Interests

The current ordinance may create impediments or conflicts for the installation of solar projects. Screening requirements for accessory equipment could impair the functionality of a rooftop or ground-mounted solar energy system. Tree preservation ordinances may hamper attempts to incorporate solar energy into a development. And, historic preservation and other appearance regulations may conflict with goals for solar development. Examining the ordinance and addressing these potential obstacles can facilitate the review and installation of solar projects.

Screening Requirements

Ordinance requirements for screening may impose unnecessary and inhibitive burdens on solar. Some jurisdictions have identified and relieved those burdens. In Asheboro, solar may be treated as mechanical equipment but is exempt from screening requirements.[77] Hendersonville, too, exempts certain solar energy systems from screening typically required for storage or utility accessories.[78] Similarly, in Fairview, roof-mounted solar equipment is not subject to typical equipment screening requirements.[79]

Tree Preservation

Tree canopy preservation is a common policy goal in many jurisdictions. Shade, of course, is at odds with a solar energy facility. Local governments may have to make trade-offs between tree preservation ordinances and solar installation. The American Planning Association Solar Briefing Paper 5 outlines this issue and identifies several communities that have sought balance.[80]

Historic Preservation

Aesthetics are of particular concern in historic districts, and new development in those districts (including solar development) requires a certificate of appropriateness. Jurisdictions may not prohibit solar accessory to a historic residence, but they are authorized to regulate the location and screening of solar panels to ensure the solar "is not incongruous with the special character of the district."[81] Thus, in historic districts local governments must carefully balance permitting solar and preserving aesthetics.

Design guidance is available from several sources. The North Carolina Solar Center, along with the National Trust for Historic Preservation and the U.S. Department of Energy, has created a document of guidelines entitled "Installing Solar Panels on Historic Buildings."[82] The office of the U.S. Secretary of the Interior provides the "Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings."[83] And, the American Planning Association's Solar Briefing Paper 5 includes discussion on preservation.[84]

---

77. Asheboro, N.C., Zoning Ordinance § 306A, www.ci.asheboro.nc.us.

78. City of Hendersonville Zoning Ordinance §§ 5-6-4.3(c); 5-19-4.3(c); 5-22-5.3.1, www.cityofhendersonville.org.

79. Fairview, North Carolina, Land Use Ordinance § 180P, http://fairviewnc.gov.

80. "Solar Briefing Papers 5: Balancing Solar Energy Use with Potential Competing Interests," American Planning Association, 2012, www.planning.org.

81. G.S. 160A-201, www.ncleg.net; 160A.400.4(d), www.ncleg.net.

82. "Installing Solar Panels on Historic Buildings: A Survey of the Regulatory Environment," U.S. Department of Energy, SunShot Initiative; North Carolina Solar Center; and National Trust for Historic Preservation, Aug. 2012, http://ncsc.ncsu.edu.

83. Anne E. Grimmer et al., "The Secretary of the Interior Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings," U.S. Department of the Interior, National Park Service, Technical Preservation Services, 2011, www.nps.gov.

84. "Solar Briefing Papers 5: Balancing Solar Energy Use with Potential Competing Interests," American Planning Association, 2012, www.planning.org.

Part IV: Solar Access and Solar Siting

The preceding discussion focuses on zoning for solar uses—where is solar appropriate and what are the appropriate standards for its use? The discussion of solar in local development regulation, however, can include other important questions—how can a property's access to sunlight be preserved and how can solar exposure be maximized for the future? Solar access ordinances protect a property owner's right to sunlight (limiting shade cast from buildings and vegetation on neighboring property). Solar siting ordinances establish standards for lot and building orientation to maximize sun exposure.

Solar access and siting necessarily require balancing of competing interests. Solar access protects the rights of one property owner but burdens the neighboring property. Additionally, solar access and siting may conflict with other laudable policy goals such as redevelopment and increased density. Chapel Hill's ordinance recognizes that appropriate levels of solar exposure will vary based on the district: "Adequate solar access is deemed to consist of varying levels of access ranging from rooftop solar access in high-intensity zoning districts to south wall solar access in low-intensity zoning districts."[1]

Solar Access

Protecting access to sunlight is fundamental to zoning. The purposes of zoning outlined in the 1926 Standard State Zoning Enabling Act included, among other things, "provid[ing] adequate light and air."[2] And the North Carolina General Statutes maintain that language.[3] Solar access ordinances seek to fulfill that purpose: to ensure adequate sunlight for a property owner. This is accomplished by limiting the shade that may be cast across property lines.

Some communities use solar access permits. When property owners install a solar energy system, they apply for a solar access permit to establish a right to some level of continued solar exposure. This permit restricts development and vegetation on neighboring property to protect the applicant's solar access. The solar access permits in the Village of Prairie du Sac, Wisconsin, ensure that the applicant will have solar exposure from 9:00 a.m. to 3:00 p.m., except for shade from structures or vegetation that existed before the permit.[4]

More commonly, communities have certain solar setbacks to minimize shading on neighboring property. Chapel Hill's ordinance recognizes that standard zoning dimensions (setbacks and so forth) "are intended to ensure adequate solar access," among other things. Chapel Hill's solar setback limits development along the northern lot line.[5] The town's solar setbacks range from 20 feet

---

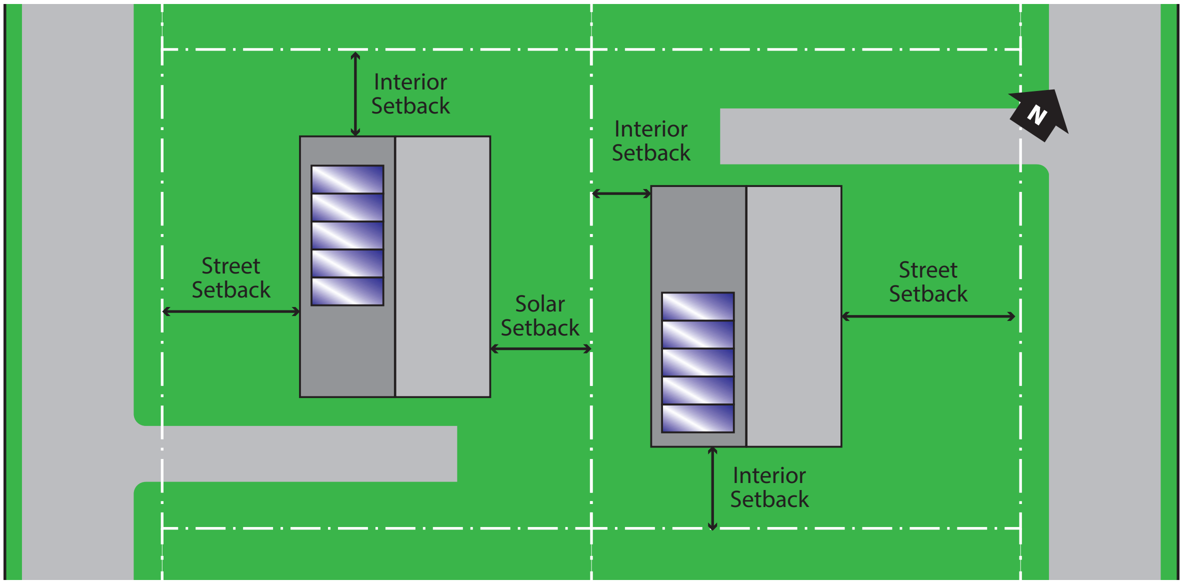
1. Chapel Hill, North Carolina, Code of Ordinances § 3.8, http://library.municode.com/HTML/19952/level3/CO_APXALAUSMA_ART3ZODIUSDIST.html.

2. A Standard State Zoning Enabling Act, Revised Edition, U.S. Department of Commerce, 1926, www.planning.org.

3. N.C. Gen. Stat. § 160A-383, www.ncleg.net.

4. Village of Prairie du Sac, Wisconsin, Land Use Regulations Ch. 8, http://prairiedusac.net.

5. "*Setback, solar:* The horizontal distance between the north lot line of a zoning lot and any structure on such zoning lot, measured along the north/south axis in a southerly direction from the north lot line. A north lot line shall be construed to include any portion of a lot's lot line which has an alignment within forty-five (45) degrees of an East/West axis." Chapel Hill, North Carolina, Code of Ordinances App. A, http://library.municode.com/HTML/19952/level2/CO_APXALAUSMA.html.



Solar setbacks protect the sun access of neighboring properties.

in low-density residential districts to 6 feet in more dense residential districts. No solar setback is required in town center, office, and mixed-use districts.[6]

Navassa's site plan review process includes examination of "the placement of structures that affect preservation of natural lighting and solar access." The reviewing board may "impose appropriate performance standards, mitigation measures, and conditions to minimize adverse impacts on adjacent properties."[7]

Solar Siting

Solar siting ordinances offer another approach to enhancing and protecting future solar access. Solar siting provisions regulate the layout and orientation of lots and buildings in order to maximize solar exposure for new and future development. Ordinances may address various topics including street design and layout, lot sizing and orientation, flexible setbacks to maximize solar access, and more.

Solar siting ordinances are less common in North Carolina as requirements, but some local governments have incorporated aspects of solar siting into approval processes. Fayetteville allows a density bonus of up to 20 percent if a project includes certain sustainable development practices. The menu of options includes solar access for 25 percent of the buildings in development and configuration on an east-west axis.[8] Chapel Hill's University-1 zoning district, a district correlated

6. Chapel Hill, North Carolina, Code of Ordinances Table 3.8-1, http://library.municode.com/HTML/19952/level3/CO_APXALAUSMA_ART3ZODIUSDIST.html.

7. Town of Navassa Zoning Ordinance § 8.1, www.townofnavassa.org.

8. Code of Ordinances, City of Fayetteville, North Carolina, § 30-5-N, http://library.municode.com/index.aspx?clientId=10733.

Solar siting ordinances ensure that subdivisions are designed for solar orientation so homeowners may use solar energy now or in the future.

with development agreements for university-related projects, includes provision for such development to address the solar access and orientation of buildings within the district.[9]

While solar access and solar siting ordinances are less prevalent than the basic solar zoning provisions, they are useful tools for facilitating solar development now and enhancing it in the future.

9. Chapel Hill, North Carolina, Code of Ordinances § 3.5.5(i), http://library.municode.com/HTML/19952/level3/CO_APXALAUSMA_ART3ZODIUSDIST.html.

Conclusion

Cities and counties across North Carolina—indeed, across the country—are witnessing a dramatic rise in solar development, and local governments are seeking to facilitate responsible solar projects. Policy decisions may differ from community to community, but the questions that arise are largely the same. How should local planning address solar? What are the appropriate development regulations? And how might regulation protect solar resources into the future? This document surveys the issues and practices from around North Carolina and beyond and provides examples and ideas to support local governments as they evaluate solar development and craft appropriate ordinances to address it.

Issues related to planning and zoning for solar surely will continue to develop. Lessons are learned, technology evolves, and politics change. What was once a new and different development type will become commonplace. Cooperation between creative developers and dedicated public servants will ensure that communities meet the challenges created by these new technologies and find innovative solutions that will foster sustainable development for years to come.

Additional Resources

Zoning and Planning for Solar

Environmental Planning and Design, LLC. "A Municipal Guidebook for Solar Zoning and Permitting." PennFuture Sunshine Team, December 2012. www.pennfuture.org.

"Planning and Zoning for Solar Energy," PAS EIP-30. American Planning Association, July 2011. www.planning.org.

Solar Briefing Papers. American Planning Association, 2012. www.planning.org.

Solar Energy Resource Center. U.S. Department of Energy. www4.eere.energy.gov/solar/sunshot/resource_center.

"Solar Powering Your Community: A Guide for Local Governments." U.S. Department of Energy, January 2011. www4.eere.energy.gov/solar/sunshot/resource_center.

Solar Roadmap: Resources. Sunshot, U.S. Department of Energy. www.solarroadmap.com.

Template Solar Energy Development Ordinance for North Carolina, Table 1. North Carolina Sustainable Energy Association and North Carolina Solar Center, December 2013. http://energync.org.

Historic Preservation and Solar

"Design Guidelines for Solar Installations." National Trust for Historic Preservation. www.preservationnation.org.

Grimmer, Anne E., Jo Ellen Hensley, Liz Petrella, and Audrey T. Tepper. "The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings." U.S. Department of the Interior, National Park Service, Technical Preservation Services, 2011. www.nps.gov.

Kandt, A., E. Hotchkiss, A. Walker, J. Buddenborg, and J. Lindberg. "Implementing Solar PV Projects on Historic Buildings and in Historic Districts," Technical Report, NREL/TP-7A40-51297. National Renewable Energy Laboratory, September 2011. www.nrel.gov.

Other Related Solar Resources

Brooks, Bill. "Expedited Permit Process for PV Systems: A Standardized Process for the Review of Small-Scale PV Systems," Revision 2. Solar America Board for Codes and Standards, July 2012. www.solarabcs.org.

DSIRE: Database of State Incentives for Renewables & Efficiency. www.dsireusa.org.

North Carolina Solar Center. http://ncsc.ncsu.edu.

North Carolina Sustainable Energy Association. http://energync.org.

Local Ordinances and Plans Cited

Archdale, N.C., Zoning Ordinance. www.archdale-nc.gov.

Community Energy Plan. Arlington County, Virginia, June 2013. http://freshaireva.us.

Asheboro, N.C., Zoning Ordinance. www.ci.asheboro.nc.us.

Brunswick County, North Carolina, Unified Development Ordinance. www.brunsco.net.

Chapel Hill, North Carolina, Code of Ordinances. http://library.municode.com/HTML/19952/level3/CO_APXALAUSMA_ART3ZODIUSDIST.html.

Currituck County Unified Development Ordinance. www.co.currituck.nc.us.

Zoning Ordinance, Davidson County, North Carolina. www.co.davidson.nc.us.

Fairview, North Carolina, Land Use Ordinance. http://fairviewnc.gov.

Code of Ordinances, City of Fayetteville, North Carolina. http://library.municode.com/index.aspx?clientId=10733.

City of Hendersonville Zoning Ordinance. www.cityofhendersonville.org.

Huntersville, N.C., Interactive Zoning Ordinance. www.huntersville.org.

Iredell County Land Development Code. www.co.iredell.nc.us.

Integrated Energy Management Plan. Loudoun County, Virginia, Feb. 29, 2012. www.loudoun.gov.

Town of Navassa Zoning Ordinance. www.townofnavassa.org.

Zoning Ordinance of the County of Pasquotank, North Carolina. www.co.pasquotank.nc.us.

Ordinance No. 88, Zoning Ordinance, Perquimans County. www.co.perquimans.nc.us.

Development Ordinance, Town of Pleasant Garden, North Carolina. http://library.municode.com/index.aspx?clientId=14932.

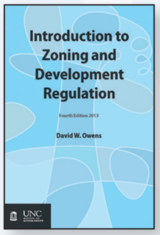
Village of Prairie du Sac, Wisconsin, Land Use Regulations. http://prairiedusac.net.

2030 Comprehensive Plan. City of Raleigh, adopted Oct. 7, 2009, amended Apr. 5, 2011. www.raleighnc.gov.

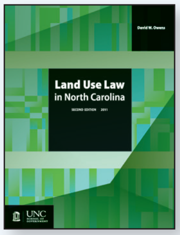
Raleigh, N.C., Unified Development Ordinance, www.raleighnc.gov.

Town of St. Pauls, N.C., Zoning Ordinances. www.stpaulsnc.gov.

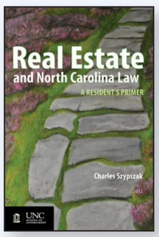
RELATED PUBLICATIONS



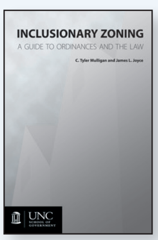
Introduction to Zoning and Development Regulation
Fourth Edition, 2013
David W. Owens



Land Use Law in North Carolina
Second Edition, 2011
David W. Owens



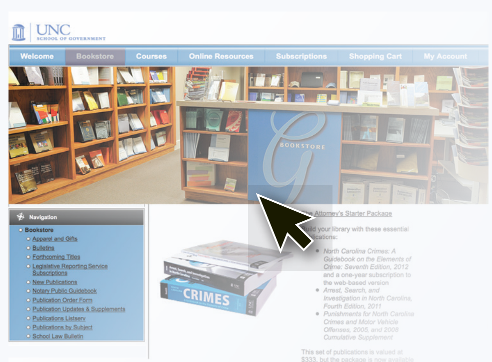
Real Estate and North Carolina Law: A Resident's Primer
2012
Charles Szypszak



Inclusionary Zoning: A Guide to Ordinances and the Law
2010
C. Tyler Mulligan and James L. Joyce

ABOUT THE AUTHOR

Adam Lovelady is an assistant professor of public law and government at the School of Government. He specializes in zoning, city and county planning, environmental protection, and historic preservation. Before joining the School of Government in 2012, he practiced law with McGuireWoods LLP in Richmond, Virginia, and taught in the Atlanta public school system as a part of Teach for America. He also worked in historic preservation in Asheville and Shelby, North Carolina, and he worked for the Southern Environmental Law Center's Land and Community Program.



Check for updates to publications:
www.sog.unc.edu/pubs/updates

Order online: www.sog.unc.edu/pubs

Contact the Bookstore: sales@sog.unc.edu or 919.966.4119

UNC School of Government

@uncsog

ISBN 978-1-56011-750-6
2014.02PDF