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An Update on North Carolina Solar Development and Decommission Policy

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Solar photovoltaic (PV) facilities in North Carolina have grown in number and size over the past decade with few geographic limitations. In 2007, North Carolina had no utility-scale solar facilities - those which generate electrical power for purchase by an entity for resale to commercial or residential customers. Now, there are in excess of 600. As a result of this growth North Carolina ranks third behind California and Texas in total investment in utility-scale solar energy facilities, and outpaces Texas in the amount of its total electricity drawn from solar (7.8% vs. 2.6%) (SEIU, 2021). North Carolina public policy has advanced concerning how solar capacity is procured and where facilities are located. However, formal discussion is only just beginning on what is to become of these facilities and their tons of equipment when they cease generating electricity.

Solar PV equipment has a limited life due to natural degradation from long exposure to weather, and the estimated end-of-life (EOL) for a solar panel is 25 years under current technology. The EOL issue is of primary concern to landowners who wish to recover the use of the land at the end of a solar lease. EOL is also a matter of concern for county governments who must approve zoning for solar PV facilities while addressing the concerns of landowners and communities over the removal of land from farm or forest production, as well as their own county waste disposal capacity. A recent report (discussed in detail below) notes that the EOL management planning horizon for disposal of the first installations is 10 years off, meaning a comprehensive waste management plan will need to be in place by 2031.

Solar PV facility leases address EOL as a contractual matter between developer and landowner. However, several areas of concern for policymakers and rural communities remain, including the ability of the developer (or their successor) to cover the costs of removal and site restoration, the fair calculation of restoration costs and hazardous waste management for the removed hardware. This article provides a brief overview of historical solar development in North Carolina, current solar development and decommission policy, a review of a recent stakeholder study on EOL issues and an illustrative example of the costs of decommission.

Solar Development in North Carolina Before 2017

Utility-scale solar facilities generate in increments of megawatts (MW). One MW can supply the ongoing electricity needs of 200 houses and requires an average of 5,068 solar panels (varying by type) which cover about 5 acres of land (NC DEQ, 2021). The most common solar PV facility one encounters while driving through North Carolina would be a facility with a MW capacity of between 2 and 10 megawatts.

In 2019, there were 601 solar PV facilities in North Carolina with one MW or greater of electricity generating capacity, with 240 generating electricity between five and ten MW. Facilities can be found in 74 counties, although the majority are in eastern North Carolina (NC DEQ, 2021). Figure 1 shows the number of facilties by MW capacity. Total capacity for North Carolina measures at 7,228MW as of 2021, with projected additions exceeding 2,595MW over the next five years (SEIA 2021).

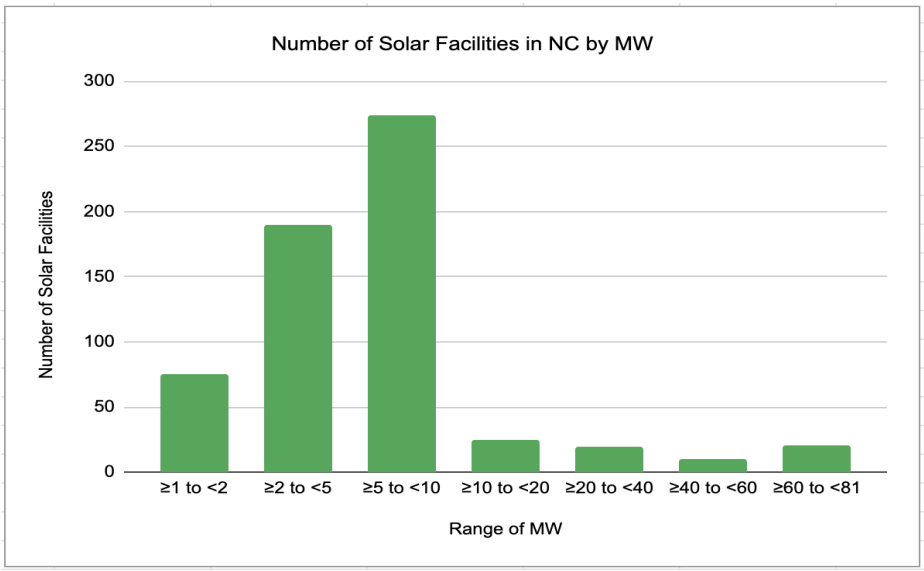

Figure 1: Number of Solar PV Facilities by MW (NC DEQ)

The majority of NC solar PV facilities have been developed on leases from landowners who retain ownership of the underlying parcel. The leases require an initial term (typically around 25 years) with two or three 5-year renewal options at the end of the lease exercisable by the developer/lessee. Such leases provide likely the highest monthly return on rural land (as compared with farm rent or conservation program payments) and given their length, are often multi-generational. Given their returns and seeming ubiquity in the rural landscape, many landowners (in author's experience) have expressed interest in attracting such leases. Most utility-scale solar projects begin with an option period whereby the developer seeks a power purchasing agreement (PPA) with an electricity buyer and raises capital for development. Duke Energy itself (through a developer subsidiary) owns and operates 35 facilities in North Carolina (Duke Energy, 2016). Private landowner "self-development" of a utility-scale facility has not been undertaken due to the costs and technical and financial complexity.

North Carolina's comparatively rapid growth in solar capacity - and leadership in the Southeast - has been the result of a number of factors, particularly North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard (REPS) (N.C.G.S. §62-1338.8). Passed in 2007, REPS requires investor-owned utilities (i.e. Duke Energy, Dominion Energy) as well as electric cooperatives and municipal utilities to purchase target percentages from renewable energy sources. Also, state and federal tax credits were offered to developers, including a property tax reduction of 80% appraised value on solar equipment (N.C.G.S. §105-275[45]). While the federal tax credit was recently extended to 2023 [26 U.S.C. §48], the state tax credit was allowed to expire in 2016 [N.C.G.S. §105-129.16A].

REPS made North Carolina the first state in the Southeast to implement a renewable energy portfolio standard. REPS also required all investor-owned utilities to source increasing percentages of their retail energy sales through renewable energy resources – including solar, wind, hydroelectric, and biomass combustion of swine and poultry waste - or energy efficiency measures. Under REPS, renewable energy targets increased over the years from 3% in 2012 to 10% in 2018, and 12.5% for 2021 and beyond [N.C.G.S. §62-133.8(b)(1)].

A Revised Procurement System: HB 589

Prior to 2017, any land parcel of favorable topography and proximity to a three-phase power line (the common 4-line power lines running alongside primary roadways) was eligible for solar development. While flat and well-drained open farmland was preferable due to lower development costs, facilities have been built on tracts of varying topography throughout the state. With no coordinated facility siting or size requirement, the result was a geographic dispersion of solar facilities throughout rural North Carolina which did not always efficiently meet the electricity service needs of purchasers.

In 2017, the NC General Assembly changed North Carolina's approach to its solar energy development with the passage of House Bill 589 [SL 2017-192, H.B. 589, § 62 (2017)] which reformed North Carolina's approach to renewable energy development and procurement – in particular the process for siting solar PV facilities. The HB 589 law was North Carolina's latest interpretation of how to meet the requirements of the federal Public Utility Regulatory Policies Act (PURPA) (Pub. L. 95–617, 92 Stat. 3117 [1978]) which requires states to implement policies of energy conservation and development of renewable resources (e.g. wind, solar and hydro).

The HB 589 law introduced the Competitive Procurement of Renewable Energy (CPRE), which established a system whereby utilities would now have "authority to determine the location and allocated amount" of renewable energy procurement in their respective areas of operation [N.C.G.S. §62-110.8(c)]. This system effectively allows public utilities to design the parameters for their needs - including location - and then through CPRE request proposals from solar facility developers for project approval. Projects up to 80MW capacity which are subject to "economic dispatch and curtailment" of the purchaser are subject to CPRE. (Economic dispatch and curtailment means the buyer may reduce, or curtail, withdrawing electricity from a particular solar PV facility as need and efficiency requires.) The former limitation enabled the utilities to bring the "develop anywhere" status quo to more align facility location by regional service needs, while the latter offers the utilities flexibility on the amount of energy drawn from such facilities. CPRE offered the promise that continuing development of ≤ 80MW facilities would proceed over four tranches of requests for site proposals; however HB589 statutory targets have been largely met, so far ending the proposal tranches at two. (Duke Energy, 2021)

EOL Decommission Policy In Development

There are several concerns regarding solar EOL, namely who will pay for the cost of decommission and how to reach a reasonable cost estimate given recycling-market uncertainty 30 to 40 years into the future. Other issues include plans to dispose of equipment under federal and state hazardous waste regulation.

Solar development leases generally require that the developer pay for costs associated with decommission and restoration of the site. However, the financial ability of a developer 30 years into the future to fulfill this obligation is speculative, as it is for any party who may purchase the lease during its term. The term "decommission" refers to disassembling the solar components (panels, cables, distribution boxes, fencing, etc.) and hauling them off the facility for disposal, and paying the costs of disposal. Decommissioning cost estimates reflect the cost of removal less the salvage value of components (MNDOC 2018), the latter calculated according to present metal salvage market prices. Restoration concerns the return of the land supporting the facility to its state prior to development, either as farmland or re-seeded for timber or some other projected use. Solar facility leases with private landowners generally require restoration, and it is a common discussion in rural communities concerned about the loss of productive land and whether it can actually be restored to a productive state. Figure 2 illustrates the number of solar PV facilities by their EOL horizon.

Figure 2: Horizon for Decomission of Facilities (NC DEQ)

Issues related to restoration include restoring permeable surface (i.e. removing paved pads and roads) and remediation of any soil contamination and lost fertility. The challenge of a lease requirement for either decommission or restoration is the potential lack of guarantee that the developer or a successor in interest will be financially able to meet these obligations as they are described in the lease. Without financial assurance at the start of development (or required at some point thereafter as the PV facility generates revenue for purchase such financial assurance instruments), these obligations are a private contract matter between the landowner and the facility owner, and the landowner may decide not to enforce in court. Concerns over decommissioning rest on the assumption that developed sites will not be upgraded for a new leasehold term. As discussed below, local communities have begun to address EOL financial assurance through their zoning approval of solar PV facilities.

In an effort to express public policy on these EOL issues, in 2019 the North Carolina legislature passed HB 329 (S.L. 2019-132), requiring the NC Department of Environmental Quality (NC DEQ) to prepare a report to guide rulemaking regarding decommission of solar PV and other renewable energy facilities

and proper disposal of their equipment. The report, titled Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment, was released in January of 2021. The report provides a thorough discussion on the EOL questions landowners and communities may have about solar decommissioning. The report compiled the input and commentary of numerous stakeholders from the renewable energy industry, environmental organizations and academia, including NC State University's Clean Energy Technology Center. Below is a summary of some of the key findings and recommendations from the report.

Volume of Potential Waste

North Carolina DEQ data reveals that the state's more than 4,000MW of solar capacity is produced by 23.3 million solar PV modules, weighing 500,000 tons. This figure is expected to double in the next five years. The DEQ report estimates that if all PV modules were disposed of today, this would account for ten percent of the total tonnage of landfill waste that was deposited in 2018-19, and eventual disposal at EOL is not expected to negatively impact landfill capacity. Given the 25-year average lifespan of solar PV modules, DEQ estimates that approximately 8.5 million PV modules will be decommissioned between 2036 and 2040, with another 8.2 million in the five years after. This represents a disposal of 364,000 tons over a ten year period, as shown in Figure 3)

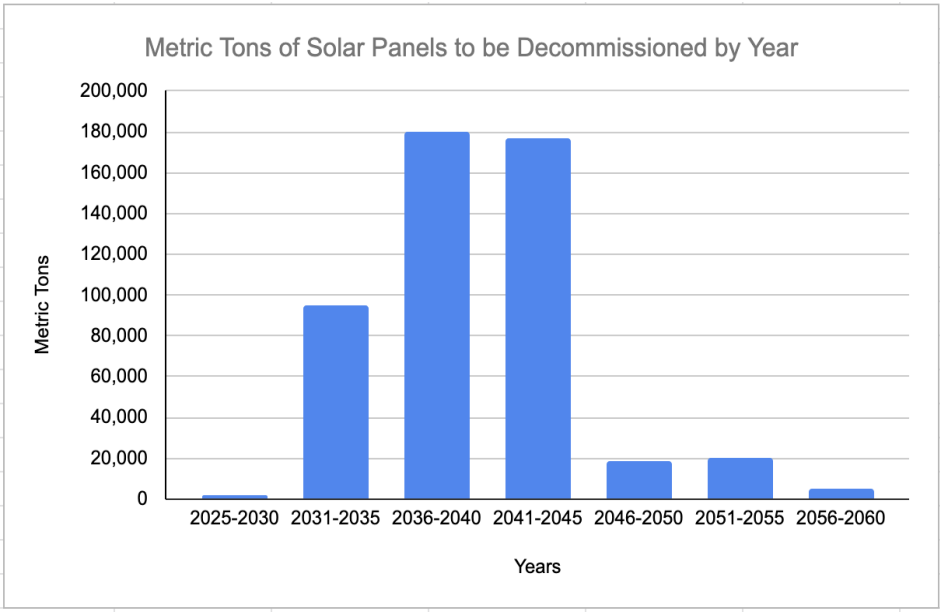

Figure 3: Volume of Solar PV Waste (NC DEQ)

The HB 329 report calls for legislation and rulemaking to add enhanced reporting requirements for facilities of 1MW or greater to aid in EOL management. It also recommends a ten-year waste management plan, which is required of other generators of industrial waste.

Solar Components as Hazardous Waste?

A common concern about solar panels is the environmental impact of their components if disposed of as routine solid waste. Under the federal Resource Conservation and Recovery Act (RCRA) [42 U.S.C. §6901 et seq. (1976)], hazardous waste - defined by the characteristics of ignitability, corrosivity, reactivity, or toxicity (40 CFR §261.21- 261.24) - may not be discarded in a solid waste landfill, and requires special handling, usually controlled incineration. Currently, solar PV panels at EOL are not classified as hazardous under RCRA or North Carolina's parallel regulations (N.C.G.S. 130A-290 et seq., 15A NCAC 13A). HB329 directed NC DEQ to make a determination whether PV modules, storage batteries or their constituent materials exhibit any of the hazardous waste characteristics identified by RCRA regulations.

Several solar PV technologies contain components that in certain concentrations may exhibit toxicity. For example, crystalline silicon solar panels – the predominant type installed in North Carolina – are 90% of their mass by weight glass, polymer and aluminum, and contain traces of copper, zinc, silver, tin and lead that generally test below toxicity test standards. Cadmium-telluride (CdTe) panels contain traces of copper, zinc, tin, and other metals, but are otherwise 98% glass, polymer, and aluminum. At EOL or earlier disposal (e.g. due to storm damage), the solar equipment is recommended to be tested under the toxicity characteristic leaching procedure (TCLP) test mandated by federal regulations (40 CFR §261.24). At that point, DEQ will make a determination as to whether the materials are classified as hazardous waste. As far as concerns about leaching prior to EOL, at least one research report suggests that these components do not pose a threat to nearby ecosystems (Robinson and Meindl, 2018). If solar PV modules are considered non-hazardous waste, they may be disposed of in municipal solid waste (MSW) landfills. Such landfills are designed according to RCRA with engineered liners, closure cap systems and leachate collection systems. The DEQ report found that even without recycling of panel materials, the estimated one million tons of disposed equipment will not negatively impact existing landfill capacity (NC DEQ, 2021).

Battery systems for off-site storage of PV electricity – still new and relatively few – have a 10-year EOL. Of the three current storage battery technologies – lithium-ion, lead-acid and nickel-cadmium – only lead-acid and nickel-cadmium are classified as hazardous wastes due to the lead (considered toxic) and cadmium, and are managed under RCRA protocols. Lithium-ion – the most prevalent and fastest-developing technology in solar PV energy storage – may be classified as hazardous waste at the time of decommission depending on the volume of components that exhibit hazardous characteristics as defined by RCRA. Whether classified as toxic or not, there is insufficient collection and storage infrastructure for lithium-ion batteries at an industrial scale in North Carolina, and recycling infrastructure is not yet developed as batteries of this technology have yet to reach EOL or otherwise be decommissioned.

Recycling Capacity Still Uncertain

The HB 329 report notes that recycling capacity for solar PV materials is still in development, adopting somewhat of a "wait and see" position on policy recommendations while new recycling technologies continue to develop closer to the earliest installations' EOL horizon. The report emphasized that sufficient infrastructure for transportation will be needed, as recycling will require hauling discarded materials to in-state facilities and further distances to facilities in other states. The report does suggest creation of an online list of energy equipment recyclers (in state and out of state) modeled on a similar registry of electronics recyclers at some future date (See N.C.G.S. 130A-309.142). One study suggests that the market for EOL solar components could reach $60 million by 2030, and $2 billion by 2050 (Weckend et al. 2016).

Financial Assurances for Decommissioning of Facilities

As noted above, concern for landowners entering a solar lease – as well as their potential heirs, neighbors and communities – is whether actual funds will be available at the time the panels, supports, wires, conversion boxes and the fencing surrounding the facility are removed when the lease term ends. Leasehold interests routinely change hands through sale, and the landowner/lessor cannot predict the financial health of the eventual owner at EOL.

The DEQ study notes that one-third of the states have adopted decommissioning standards, half of which address financial assurance, the guarantee of available funds at future date of decommission.

Though North Carolina does not yet have a statewide policy on decommissioning, 56 counties have passed ordinances concerned with decommissioning, of which 24 require some form of financial assurance in the varying form of surety bond, certified check, irrevocable letter of credit or cash escrow. Such instruments ensure that decommission funds have been set aside and cannot be reclaimed by the developer. Some NC counties allow estimates of salvage value to offset the financial assurance amount. Beaufort, Hertford and Warren Counties do not require financial assurance, and state that if the owner cannot pay for decommission and removal, it becomes the responsibility of the landowner. The HB329 report recommends deferring for five years the study of a mandated financial accountability requirement, suggesting that a statewide policy on financial assurance requirement is some years off [NC DEQ 2021]. Figure 4 (below) illustrates the distribution of counties which by ordinance require decommission plans, including those that require financial assurance.

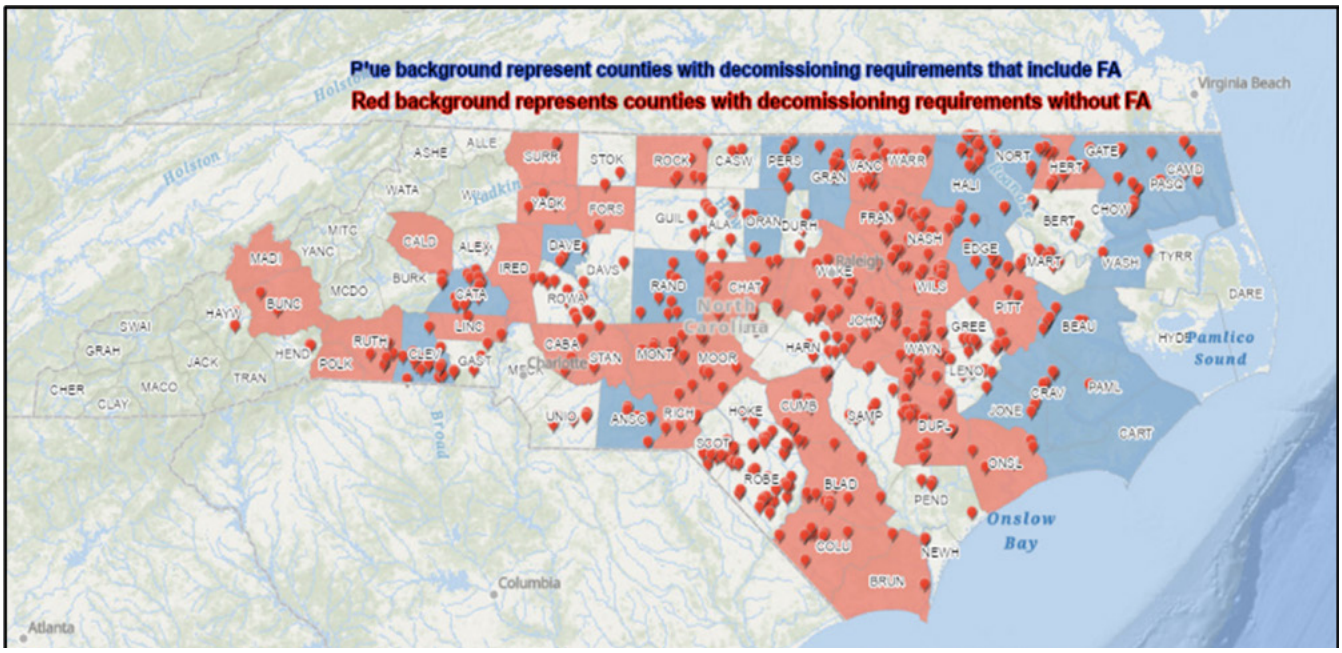

Figure 4: Distribution of County Decommission Plan Requirements (NC DEQ)

Projections on Costs of Decommission (and Recycling/Scrap Offset)

One window into the costs of decommission and restoration may be found in a 2017 report commissioned by Duke Energy Progress (DEP) concerning the decommission of various facilities it owns, including gas and coal-fired, hydroelectric electric and solar plants. The report projects removal costs for four of DEP's solar facilities.

A review of the decommission cost estimates for DEP's Elm City Solar Facility provides an example of removal cost and recycling offsets estimates. The Elm City facility - located in Wilson County - is a 40MW facility with 487,520 thin film fixed panels covering 450 acres. The study estimated the gross removal cost at $6.3M. The components of the estimated cost are summarized in Figure 5 (next page).

Elm City's total salvage value of $1.9M includes a steel scrap values $140.37/ton, an aluminum scrap value of $0.40/lb, and copper scrap value of $1.70/lb for a net decommission/restoration cost of $4,419,000 (DEP 2017). The DEP Elm City estimates come from materials published by the American Metal Market in 2017. By way of comparison, an October 2021 review of scrap indices reveals the

following: steel scrap at $167.00/ton; aluminum scrap at $0.58/lb; copper scrap at $3.17/lb (www.iscrapapp.com). Such figures often accompany an estimate of salvage value, which can either off-set or absorb the removal cost, which itself becomes the dollar measurement of any financial guarantee on the part of the developer.

The estimated costs of decommission vary, often lacking the details of the DEP plan. A proposed 960 acre facility in Halifax County, Virginia (which borders Person County, NC) has an estimated removal cost of $2.0M (Maamari, 2018). Another source of estimates may be found in decommission plans filed by developers seeking zoning approval. As noted in the HB329 study, a number of county zoning ordinances require filing of a decommission plan as a requirement of zoning approval. However, further research is required to acquire and consolidate the estimates found in these decommission plans.

	Labor	Material and Equipment	Disposal	Environmental	Total Cost	Scrap Value
Elm City						
Unit 1						
Substation	$ 11,000	$ 3,000	$ -	$ -	$ 14,000	$ -
Solar Panel Removal/Recycling	$ 1,151,000	$ 303,000	$ 336,000	$ -	$ 1,790,000	$ -
Solar Panel Support	$ 1,088,000	$ 287,000	$ -	$ -	$ 1,375,000	$ -
Cables and Wires	$ 146,000	$ 38,000	$ -	$ -	$ 184,000	$ -
Transformer and Inverter Block	$ 165,000	$ 43,000	$ -	$ -	$ 208,000	$ -
Combiner Boxes	$ 3,000	$ 1,000	$ -	$ -	$ 4,000	$ -
Roads	$ -	$ -	$ -	$ 70,000	$ 70,000	$ -
Perimeter Fence Removal	$ 143,000	$ 38,000	$ -	$ -	$ 181,000	$ -
Site Restoration	$ -	$ -	$ -	$ 1,144,000	$ 1,144,000	$ -
On-site Concrete Crushing and Removal	$ -	$ -	$ 11,000	$ -	$ 11,000	$ -
Debris	$ -	$ -	$ 41,000	$ -	$ 41,000	$ -
Scrap	$ -	$ -	$ -	$ -	$ -	$ (1,858,000)
Subtotal	**$ 2,707,000**	**$ 713,000**	**$ 388,000**	**$ 1,214,000**	**$ 5,022,000**	**$ (1,858,000)**
Elm City Subtotal	**$ 2,707,000**	**$ 713,000**	**$ 388,000**	**$ 1,214,000**	**$ 5,022,000**	**$ (1,858,000)**
TOTAL DECOM COST (CREDIT)					**$ 5,022,000**	**$ (1,858,000)**
PROJECT INDIRECTS (5%)					**$ 251,000**	
CONTINGENCY (20%)					**$ 1,004,000**	
TOTAL PROJECT COST (CREDIT)					**$ 6,277,000**	**$ (1,858,000)**
TOTAL NET PROJECT COST (CREDIT)					**$ 4,419,000**	

Figure 6: Illustration of Elm City Cost Estimate Removal (Duke Energy Progress)

Conclusion

North Carolina still ranks high nationally in solar MW capacity, and HB 589 has tailored size and location decisions to utility purchaser requirements on how they will meet their renewable energy purchase obligations under federal policy. However, high solar capacity comes with a large amount of materials that will need to be removed, transported and disposed of beginning a decade from now. While county zoning officials and contract negotiations between landowners and developers have provided for some financial assurances of funds available for decommission, such assurances are not yet a matter of state policy. Further, such assurances lack a firm state policy on the extent to which predicted salvage values of solar equipment will be allowed to offset the cash required for their removal and safe disposition. The real costs of decommission and the stability of financial assurances is worthy of continuing study.

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