The Solar Economy

Widespread Benefits for North Carolina

Duke
CENTER on GLOBALIZATION, GOVERNANCE & COMPETITIVENESS
at the Social Science Research Institute

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About the Duke Center on Globalization, Governance & Competitiveness

The Center on Globalization, Governance & Competitiveness (**CGGC**), an affiliate of the Social Science Research Institute at Duke University, is built around the use of the Global Value Chain (GVC) methodology, developed by the Center's Director, Gary Gereffi. The Center uses GVC analysis to study the effects of globalization on various topics of interest, including industrial upgrading, international competitiveness, the environment, global health, engineering and entrepreneurship, and innovation in the global knowledge economy. More information about CGGC is available at http://www.cggc.duke.edu.

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Report design & layout by Winking Fish

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ACRONYMS

AC	Alternating Current
BOS	Balance of System
CGGC	Center on Globalization, Governance & Competiveness (Duke)
CPV	Concentrated Photovoltaics
DC	Direct Current
EIA	Energy Information Administration
EPC	Engineering, Procurement and Construction
GVC	Global Value Chain
GW	Gigawatt (1 billion watts)
IREC	Interstate Renewable Energy Council
ITC	Investment Tax Credit
kW	Kilowatt (1,000 watts)
MACRS	Modified Accelerated Cost Recovery System
MLP	Master Limited Partnership
MW	Megawatt (1 million watts)
NCDOR	North Carolina Department of Revenue
NC-RETS	North Carolina Renewable Energy Tracking System
NCUC	North Carolina Utilities Commission
NREL	National Renewable Energy Laboratory
O&M	Operations and Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaic
QF	Qualifying Facility
REIT	Real Estate Investment Trust
REPS	Renewable Energy and Energy Efficiency Portfolio Standard
RETC	Renewable Energy Tax Credit
RPS	Renewable Energy Portfolio Standard
VC/PE	Venture Capital/Private Equity
WTO	World Trade Organization

Executive Summary

North Carolina is the South's leader, and fourth among U.S. states, in using solar power to diversify its portfolio of electric power generation fuels. A sunny climate, investor and business-friendly policies, and capable companies across the solar power value chain have made North Carolina's leadership position possible.

The benefits of being the South's leader in solar power have accrued to North Carolinians across the state. All regions – West, Central and East – and both rural and urban areas have profited from solar power investments. North Carolinians also receive gains from the economic, environmental and social benefits of less-polluting electric power generation. To paraphrase one company executive we interviewed, North Carolina is good for solar, but solar has also been very good for North Carolina.

While the present is bright, uncertainty exists in North Carolina's solar future. Three policy issues affect the future of North Carolina's continued development of large-scale solar: (1) the expiration on December 31, 2015 of the state-level renewable energy tax credit, which has been in place at some level since 1977; (2) the reduction of the federal investment tax credit from 30% to 10% on December 31, 2016; and (3) the backlog of interconnection agreement assessments acting as a block to the timely completion of solar power projects.

Report Objectives

The purpose of this report is to assess three issues related to North Carolina's utility-scale photovoltaic solar investments, which we define as a solar facility equal to or greater than 1 MW_{ac}, (1 megawatt, alternating current) or, in non-technical terms, large-scale solar used to generate electricity for business use or to be placed on the bulk power grid. The first issue investigated is the condition of the solar market: the industry, market and technology trends affecting the cost and feasibility of additional investments in utility-scale solar in the world generally and in the United States and North Carolina in particular.

The second issue investigated in this report is the amount of utility-scale solar resources in North Carolina relative to other places in the United States and the world. We find that solar resources, or *insolation*, in North Carolina are quite significant when compared to other states and countries. Clearly North Carolina has the necessary sunny climate needed to be a leader in solar electric power generation. We then turn toward better understanding the existing and planned solar power plant installations in North Carolina. From 2008 through mid-December 2014, 150 solar facilities with 573 MW in total solar capacity have been installed, and another 377 solar facilities with 3,034 MW of solar capacity are in various stages of planning and development.

The third issue examined in this report is the economic footprint of utility-scale solar in North Carolina. Our assessment of the North Carolina utility-scale solar value chain finds that the direct investments in solar affect thousands of jobs across the state.

North Carolina:

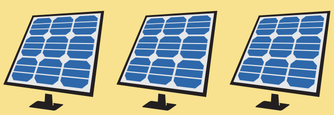
#1

in the South

#4

in the country

for installed solar capacity.



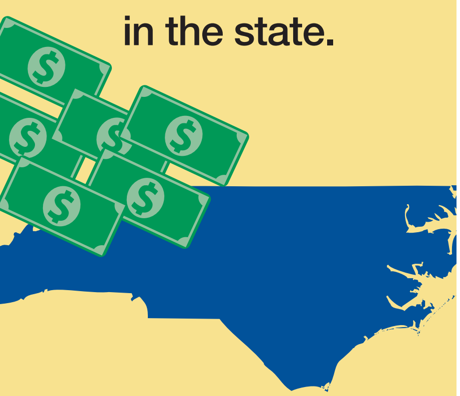
North Carolina is home to over

450 companies

involved in the solar industry— they represent at least

$2 billion

of direct investment in the state.



KEY FINDINGS

Finding #1

Solar-friendly policies have made **North Carolina No. 1 in the South and No. 4 in the country** for installed solar investment. **All parts of the solar value chain – investors, solar developers, construction contractors, solar panel and component manufacturers – are creating jobs and providing landowners, workers and towns across North Carolina with income and tax revenue.**

- Despite having the same amount of sun exposure as other states in the South, North Carolina has attracted a disproportionate share of solar industry investment – as evidenced by its No. 1 ranking in the South and No. 4 ranking nationally – due to its solar business-friendly policies.
- North Carolina is well-positioned in all parts of the solar value chain, including investors (e.g., Bank of America of Charlotte and Blue Cross & Blue Shield of Durham), developers (e.g., O2 Energies of Cornelius), construction contractors (e.g., Horne Brothers of Fayetteville), solar panel manufacturers (e.g., DuPont of Fayetteville), and component manufacturers (e.g., Schletter of Shelby for racking, ABB of Raleigh for inverters, and Torpedo Specialty Wire of Rocky Mount for electrical wiring).
- North Carolina is home to over 450 companies involved in the solar industry, and they support approximately 4,307 jobs and represent at least $2 billion of direct investment in the state.

Finding #2

The solar industry's growth in North Carolina is **providing jobs and economic development opportunities to all parts of the state, including rural areas** that have struggled historically to create jobs and businesses.

- Utility-scale solar installations are growing from North Carolina's mountains to the coast.
- Some of the highest levels of investment are occurring in North Carolina's rural counties. Catawba, Robeson and Wayne are the leading counties in the state for utility-scale solar investment.

Finding #3

North Carolina's ability to continue attracting companies in the solar industry, create jobs and promote economic development throughout the state is at risk unless policy makers act.

- Uncertainty surrounding the continuation of existing state policies has the potential to slow the growth of North Carolina's utility-scale solar industry. The challenges include:
  - Expiration of the North Carolina Renewable Energy Investment Tax Credit at the end of 2015.
  - Attempts to repeal the North Carolina Renewable Energy and Energy Efficiency Portfolio Standard (REPS).
  - Interconnection bottlenecks that are slowing the ability of solar projects to connect to the grid.

1. Introduction

1.1 Report Overview

The purpose of this report is to conduct an assessment of three major issues related to North Carolina's utility-scale photovoltaic (PV) solar investments.[1] The first issue is the state of the solar market: the industry, marketplace and technology trends affecting the cost and feasibility of additional investments in utility-scale solar in the world generally and in the United States and North Carolina in particular.

The second issue investigated in this report is the amount of utility-scale solar resources in North Carolina relative to other places in the United States and the world. We find that solar resources, or *insolation*, in North Carolina are quite significant when compared to those of other states and countries. Clearly, North Carolina has the sunny climate needed to be a leader in solar electric power generation. We then turn our attention to the existing and planned solar power plant installations in North Carolina. We find that North Carolina ranks fourth among U.S. states in terms of installed capacity and sixth in terms of electric power generation from solar resources.[2]

The third issue examined in this report is the economic footprint of utility-scale solar in North Carolina. As in many of CGGC's reports on environmental technologies, we use the value chain analytic framework to understand the industrial organization and development impacts of the solar power industry in North Carolina. Value chain studies provide insight into how goods and services are made, and they describe the many actors and economic forces present within the industry, from developers, manufacturers, installers and end purchasers to the supporting policies and organizations important to the success of an industry in a region.

Our assessment of the North Carolina utility-scale solar value chain finds that at least $2 billion in direct investment has been made in the state, affecting at least 4,307 direct jobs in 450 companies. Between 2008 and mid-December 2014 (the last date for which official statistics are available), 150 solar facilities with 573 MW in total solar capacity have been installed. Another 377 solar facilities with 3,034 MW of solar capacity are in various stages of planning and development, although it is uncertain how many of those projects will be completed.[3] Aside from these impressive impacts, a remarkable aspect about utility-scale solar in North Carolina is the degree to which its impacts are spread across all regions of the state: Western, Central, and Eastern and both rural and urban areas all receive the benefits of utility-scale solar. Overall, we agree with the perspective offered by John Morrison of Strata Solar, who said, "North Carolina is good for solar, but solar is also very good for North Carolina. This includes not only the environmental benefits of solar, but the economic benefits from what we're doing. It's the employment, the people we've trained, and the tax revenue that goes to local counties in very rural, poor parts of the state. And then there is

> *"One of the things that I want people to understand is that North Carolina is good for solar, but that solar is also very good for North Carolina."*
>
> *– John Morrison, Strata Solar*

what solar means to the landowners, the farmers, who are able to receive a long-term, fairly secure income for leasing a portion of their property for a solar farm."

1.2 Report Organization

The report is organized into four sections:

Solar Market Overview:
Analyzes the industry, market and technology trends affecting the level of adoption of photovoltaic solar power in North Carolina. The industry appears hopeful that technology and installation costs will continue to decline, making PV solar power ever more competitive within the portfolio of renewable resources for electric power generation.

Utility-scale solar in North Carolina:
Summarizes the photovoltaic resources and the amount of installed and proposed solar capacity in the state. The source for this capacity summary is filings with the North Carolina Utilities Commission (NCUC), which represent the most accurate assessment of solar capacity in the state available. Proposed solar capacity figures represent solar facilities at various stages of planning and development, but no certainty exists whether or when the facilities will be built.

The utility-scale PV solar value chain:
Describes the solar power value chain, the key segments and sub-segments in the chain, the companies that participate in each segment of the value chain, and the supporting policies and organizations in the chain.

The appendices and endnotes provide additional detail and supporting information to the narrative and analysis provided in the main text.

2. Solar Market Overview

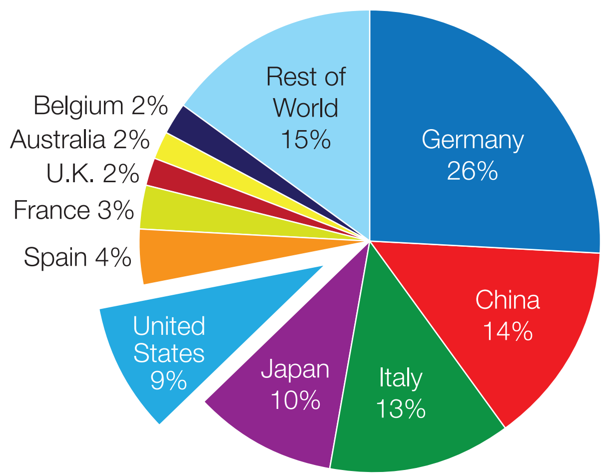
2.1 Industry Trends

The global solar PV industry has grown rapidly over the last 10 years. In 2004, global capacity was estimated at 3.7 GW, with a total annual investment of $4 billion. In 2013, global solar PV capacity was estimated at 139 GW, with a total annual investment of just under $100 billion, a 3,600% change in capacity and a 2,400% change in investment from 2004.[4] Almost half of all operating PV capacity in the world was added in the past two years.[5]

In 2013, the United States represented 9% (12.1 GW) of global PV solar capacity (see Figure 1). Approximately 4.8 GW of that was newly installed PV solar capacity and 2.8 GW was at the utility scale.[6] At the end of 2013, North Carolina had approximately 375 MW of installed capacity,[7] and by mid-December 2014 it had 573 MW of installed solar capacity.[8]

In 2013, newly installed capacity was largely the result of falling prices for PV panels and installation.[9] Large ground-mounted projects represented more than 80% of capacity additions, which are being made by commercial businesses as well as utilities. The primary motivation for commercial businesses to invest in their own solar plants is to reduce energy costs, with excess capacity being sold to utilities through long-term contracts.[10] Utility development of PV capacity, though sometimes based solely on the price of solar versus alternatives,[11] is largely affected by the Renewable Energy Portfolio Standard (RPS) and Renewable Energy and Energy Efficiency Portfolio Standard (REPS) targets in the state. The addition of new projects by utilities may slow as utilities approach their RPS and REPS targets, and industry observers have already noted that investment has slowed in some states for this reason.[12]

Figure 1: 2013 Solar PV Global Capacity, by Country



Source: Ren21 *Global Status Report,* 2014 (Table R7 and Table 12)

The size of projects also has grown, with the United States leading the world in projects of 50MW or greater. By early 2014, more than 1,430 MW of U.S. capacity existed in these large projects.[13] As mentioned by REN21's 2014 Global Status Report, it is emblematic of the rapid changes in the PV market that large-scale projects worthy of note were 200kW in 2011, 20 MW in 2012, 30 MW in 2013, and 50 MW in 2014. The increased scale of solar PV projects appears to be an unimpeded industry trend.[14] The Solar Foundation's *National Solar Jobs Census 2014* found that the U.S. solar industry employed 173,807 U.S. workers as of November 2014.[15] In 2014, an estimated 4,307 employees in North Carolina worked in companies associated with the solar industry, and these companies had an estimated $1.6 billion in revenues.[16]

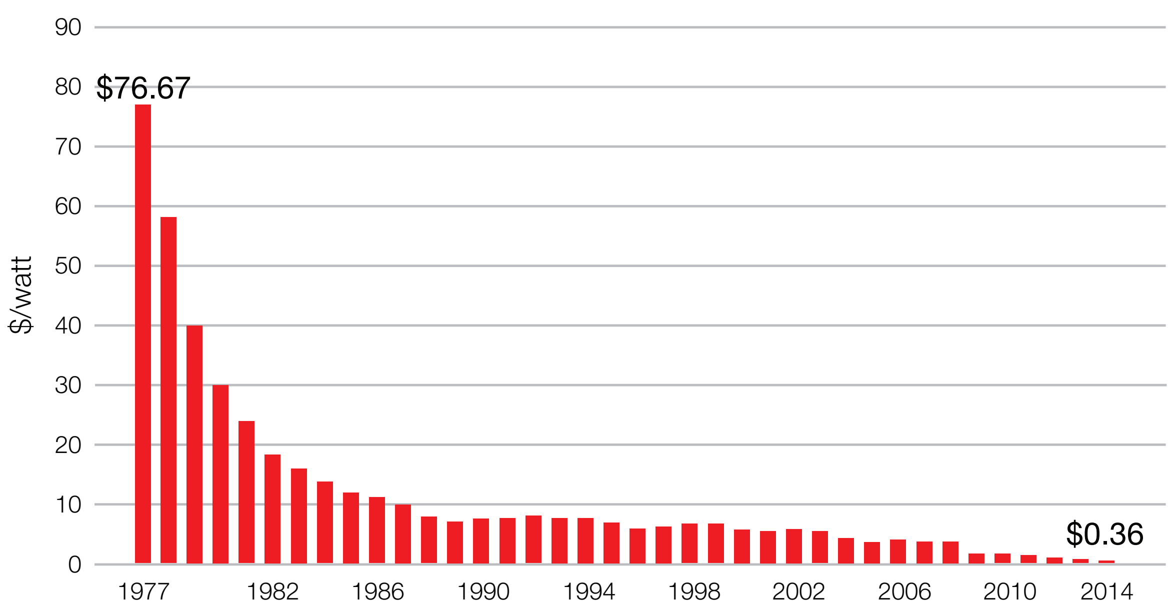
2.2 Market and Technology Trends

Manufacturing: Production costs for PV modules have declined significantly (see Figure 2). As of Q3 2014, polysilicon was $21.70/kg, wafers $0.22/W, cells $0.41/W, and modules $0.73/W.[17] Module cost reduction is largely due to lower material costs, especially for polysilicon, improved manufacturing processes and economies of scale.[18]

An estimated 43GW of crystalline silicon cells and 47GW of modules were produced globally in 2013, a 20% increase from 2012. Global production capacity of crystalline photovoltaics is estimated at 67.6 GW. Thin-film production has risen more than 20% since 2012 to 4.9 GW, but capacity and thin-film's share of global PV production has remained flat.

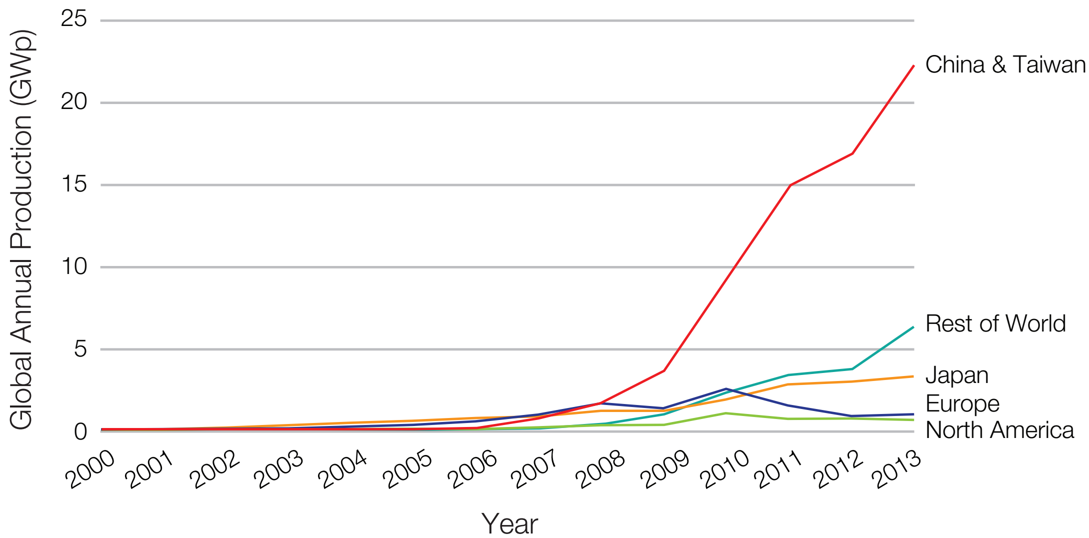
Since 2009 module production has been dominated by China, which accounts for 67% of global production (see Figure 3). Other Asian nations accounted for another 20% of production. CGGC interviews with solar companies noted an ongoing production shift away from China to other Southeast Asian countries as the industry seeks to further reduce production costs and overcome tariff barriers imposed on Chinese manufacturers by the United States. India, a promising manufacturer of solar PV, has idled most of its production due to lack of scale, the unavailability of low-cost financing, and anemic supply chains.[19] European production fell from 11% of global production in 2012 to 9% in 2013. The United

Figure 2: Price History of Silicon PV Cells, 1977-2014



Source: Bloomberg, *New Energy Finance*; pv.energytrend.com; Forbes.com

Figure 3: Global Annual PV Production, by Country, 2000-2013



Source: Fraunhofer ISE, *Global Photovoltaics Report*, 2014

States maintains 2.6% of global PV solar cell module production, of which 90% is crystalline silicon photovoltaics, 9% thin film, and 1% other, by value of shipments.[20] The U.S. industry comprises 122 companies employing 12,575 people. Ohio (thin-film), Tennessee (silicon) and California (silicon) are the leading U.S. states manufacturing PV modules. In 2012, North Carolina reported 94 peak kW in silicon PV module production, accounting for 0.01% of U.S. production.[21]

Solar inverters have rapidly developed to become one of the more sophisticated technologies supporting grid management.[22] The inverter is a crucial subsystem, converting DC to AC and holding the solar arrays close to their peak power point. ABB (Switzerland) acquired Power-One (U.S.) to become one of the world's largest manufacturers of solar power inverters. Competitive pressures have led to reduced prices for inverters as the focus for cost-cutting in the solar PV market.[23] In 2013, the average cost of inverters declined 15-18% from previous-year levels. Racking systems also declined 19-24% in 2013 due to increased competition among utility racking manufacturers.[24]

Imports and Exports: In 2012, the latest year for which data are available, U.S. imports of PV modules came primarily from China (35%) and Malaysia (33%). Imports from China largely consisted of silicon PV modules, accounting for 53% of silicon PV modules imported to the United States. Imports from Malaysia were primarily in thin-film PV modules, accounting for 88% of thin-film PV module imports. Mexico, the Philippines and South Korea each had more than a 5% share of imports, almost exclusively in silicon PV modules.[25] The sourcing of solar cells by North Carolina solar developers is significantly affected by price. Ongoing trade disputes between the United States and China (discussed in the policies section 4.2.4.1), have affected the purchasing decisions of North Carolina solar developers.

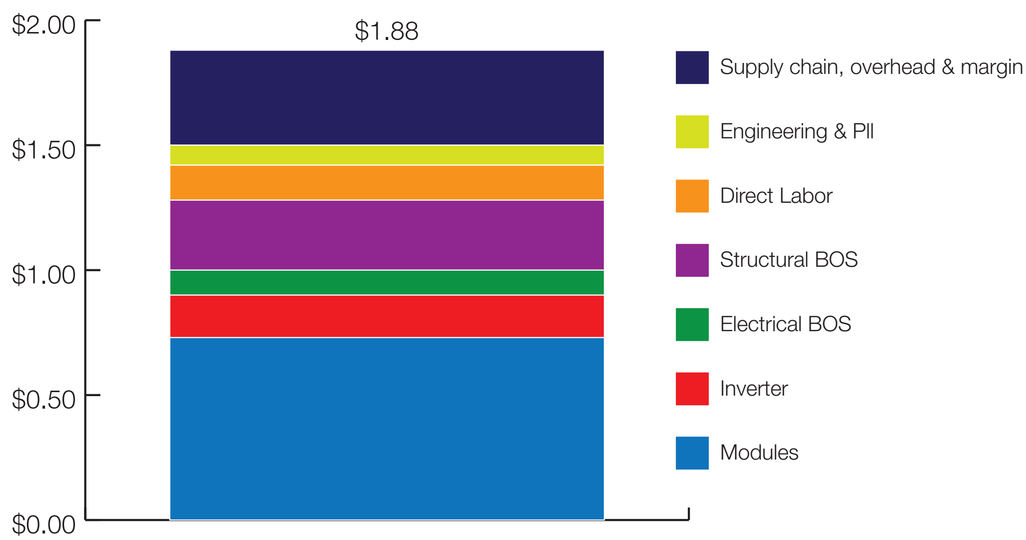
Exports of U.S.-manufactured PV modules in 2012 were directed to Japan (24.3%), India (18.5%), Germany (11.9%) and Italy (10.3%). The predominant type of export shipment was crystalline silicon modules, accounting for about 72% of total U.S. exports.[26]

Installation: Reductions in the costs of materials ("hard costs") and installation ("soft costs") reduced costs for utility-scale solar systems by 61% since the beginning of 2010.[27] Average installation costs for PV solar in Q3 2014 were \$1.88/W, down from about \$10/W in 2002. SEIA reports that installation costs during Q3 2014 were \$1.88/W_{dc} (Figure 4), with a range of \$1.55/ W_{dc} for new markets with lower component and EPC margins to \$2.10/W_{dc} for legacy power purchase agreements (PPAs) with higher component costs.[28]

Technology Changes: Solar cell efficiency continues to increase, with the National Renewable Energy Laboratory (NREL) recording significant new records in solar cell efficiency across a number of different solar cell technologies (see Figure 5). Crystalline silicon and thin-film technologies remain the two major cell technologies used in utility-scale solar projects. Other technologies, notably concentrated photovoltaics[29] (CPVs) and to a lesser degree perovskite cells,[30] offer significant potential for increased efficiency and reduced costs. Due to a number of ongoing technology changes, cell costs will likely continue to decline.

Mergers & Acquisitions: Market consolidation is a theme in PV solar, as large companies are purchasing smaller firms with promising technologies and building partnerships to expand into new markets. Examples include First Solar's acquisition of GE's cadmium telluride division and its announcement of a partnership with GE to further develop thin-film PVs.

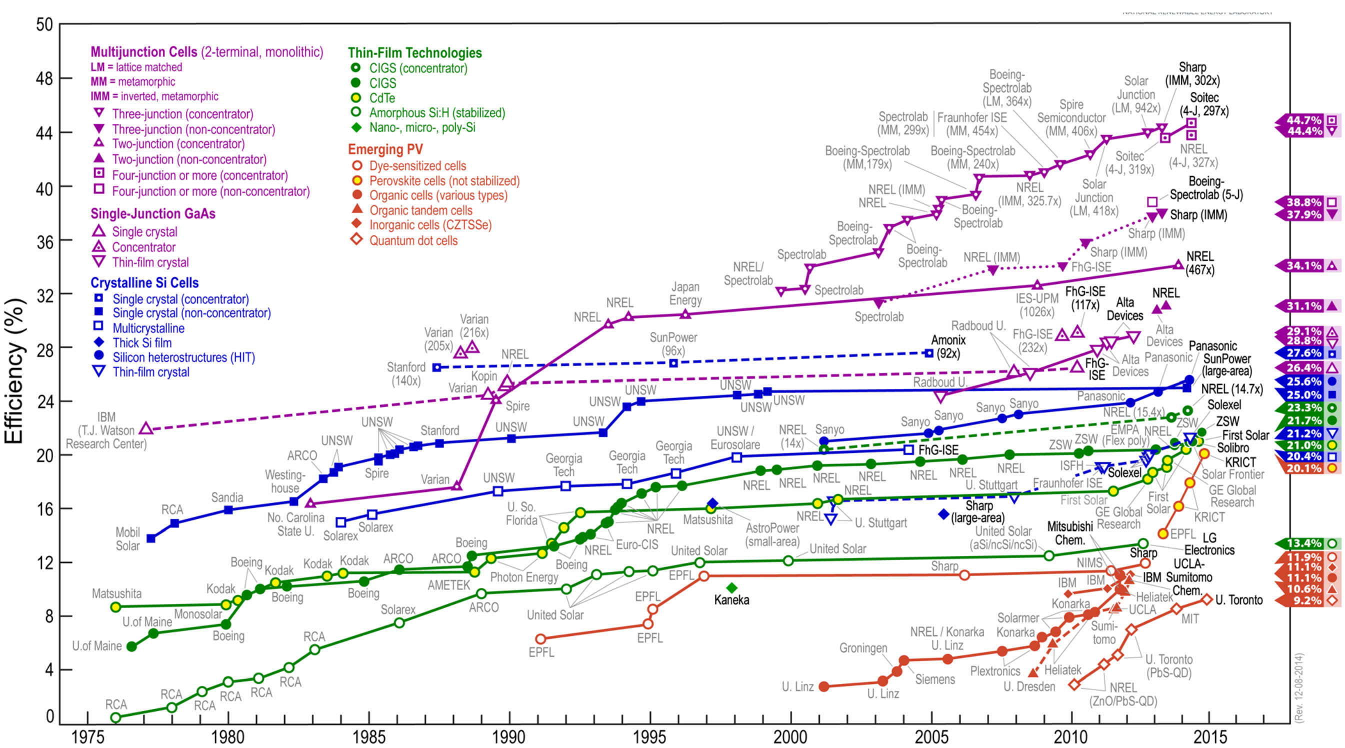
Figure 4: Utility PV System Pricing, Q3 2014, by Cost Category



Note: Assumes a 10MW horizontal fixed ground-mount system with standard crystalline silicon. BOS = balance of system.

Source: SEIA, 2014

Figure 5: Best Research-Cell Efficiencies, by Technology, 1975-2014



Source: U.S. National Renewable Energy Laboratory (NREL) 2014, “Best Research Cell Efficiencies”

Expansion across the value chain into project development, operations and development is also a theme in the industry. For example, panel manufacturer Kyocera (Japan) announced plans to develop solar farms for institutional clients in the United States, and Hanwha Q Cells USA began offering product and services across the PV value chain.[31]

Financing: Innovative financing models are emerging. Securitization, master limited partnerships, real estate investment trusts (REITs), yield companies (YieldCos) and crowd funding (whereby individuals make small investments via the Internet in specific projects) are existing or potential new entrants into the solar market. In 2013, NRG Energy developed a tradable, dividend-producing YieldCo that includes both utility-scale and rooftop solar projects.[32] In early 2014, Mosaic, an online company based in the United States, began financing more than $5 million of solar project investments through crowd funding.[33] Nine institutional projects in North Carolina are currently partially funded by Mosaic investors.[34]

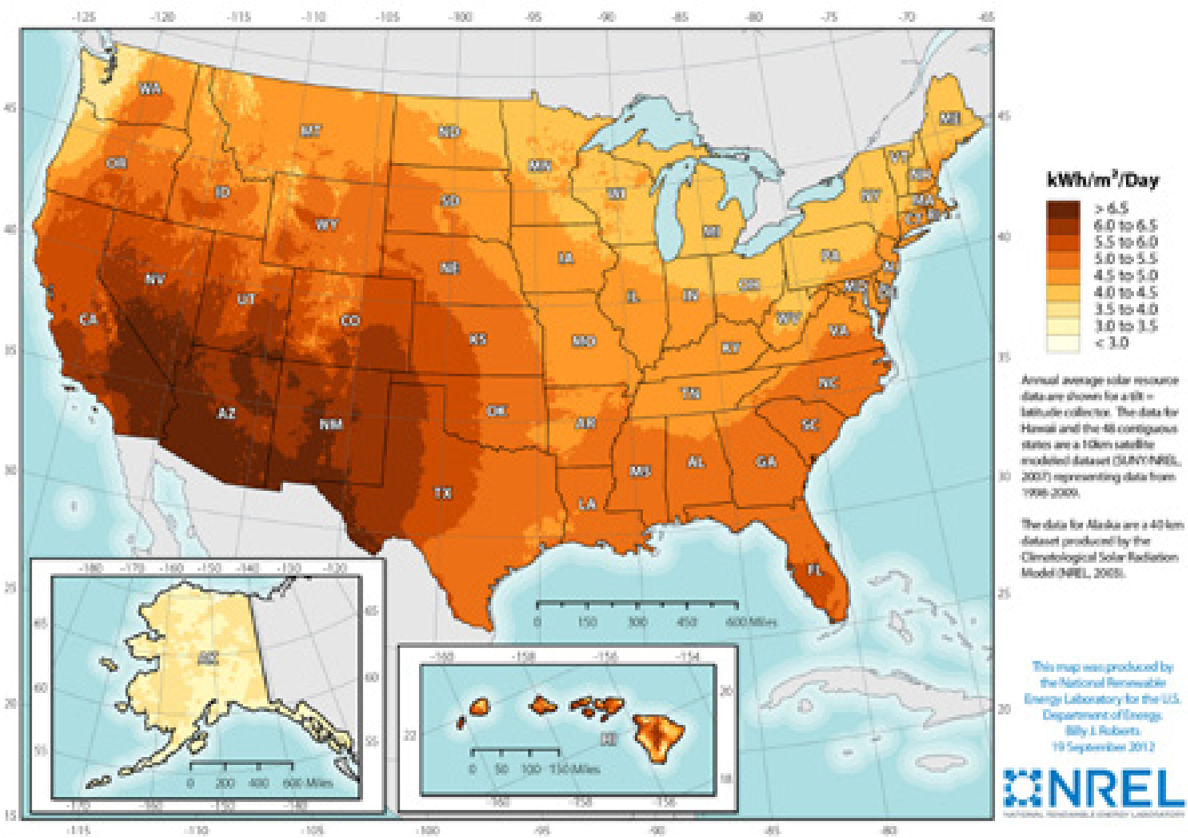
3. Utility-Scale Solar in North Carolina

3.1 Solar Photovoltaic Resources in North Carolina

North Carolina has significant PV solar resources – averaging 5-5.5 kWh/m²/Day – compared to other U.S. states (Figure 6).[35] North Carolina has as much sun available for solar power generation than other states in the South, with the exception of portions in Florida.

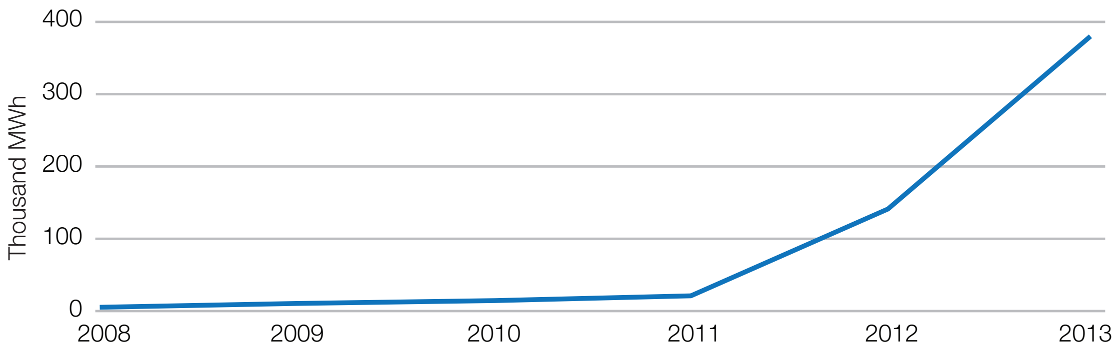
In 2013, the United States had approximately 12.1 GW of installed solar power generation and in that year added 4.8 GW of newly installed PV solar capacity, 2.8 GW at the utility scale.[36] According to the Interstate Renewable Energy Council (IREC), North Carolina had

Figure 6: Photovoltaic Solar Resources of the U.S.



Source: NREL

Figure 7: Net Solar Power Generation in North Carolina, 2008-2013



Source : EIA,2013 *Electricity Generation and Consumption* (EIA-906/920/923), table 1.6

Table 1: 2013 State Rankings of Solar Capacity and Solar Power Generation

Rank	State	Installed Solar Capacity (MW)
1	California	4,146
2	Arizona	1,250
3	New Jersey	948
4	North Carolina	375
5	Massachusetts	356
6	Nevada	339
7	Colorado	288
8	Hawaii	286
9	New Mexico	206
10	New York	193
11	Texas	173
12	Pennsylvania	144
13	Maryland	140
14	Florida	110
15	Georgia	88

Rank	State	Solar Power Generation (thousand MWh)
1	California	3,865
2	Arizona	2,041
3	Nevada	749
4	New Jersey	546
5	New Mexico	414
6	North Carolina	379
7	Florida	240
8	Colorado	199
9	Texas	176
10	Massachusetts	109
11	Pennsylvania	82
12	Maryland	80
13	Illinois	64
14	Ohio	64
15	Delaware	57

Note: Installed solar capacity is total grid-connected PV installations in MW at the end of calendar year 2013, as reported by IREC, "U.S. Solar Market Trends," July 2014. Reported DC converted to AC.

Source: Solar capacity, IREC, "U.S. Solar Market Trends 2013," 2014; power generation, EIA 2013, Electricity Generation and Consumption (EIA-906/920/923), Net Generation by State by Sector (table 1.6) approximately 375 MW of total grid-connected PV installations at the end of 2013.[37] It ranked fourth among U.S. states by installed capacity and sixth by power generation.[38] Our estimate of existing solar capacity in North Carolina, as of mid-December 2014, is 573 MW, suggesting the addition of roughly 200 MW of added capacity in 2014. We report in the next section details about existing and planned capacity in North Carolina.

3.2 Existing and Planned Solar Facilities in North Carolina

According to NCUC documents, the state had 150 operating solar facilities with 1 megawatt or more in nameplate capacity as of mid-December 2014. The facilities total 573 MW in nameplate capacity and $2 billion in total investment.[39] The facilities range from the many 1 MW plants throughout the state to the 12.4 MW Washington White Post Solar Farm in Beaufort County. The largest facilities operating in North Carolina are listed in Table 2.

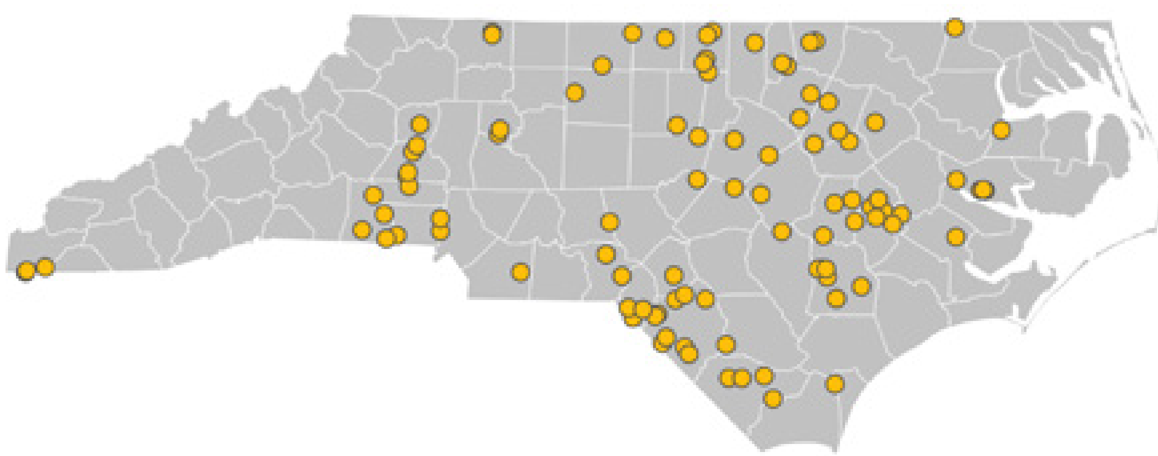
Table 2: Top Solar Facilities Operating in North Carolina, 2014

Facility	County	Capacity (MW)
Washington White Post Solar	Beaufort	12.40
Conover PV2 - DEL1	Catawba	9.73
Conover PV2 - DEL2	Catawba	9.73
Dixon Dairy Road	Cleveland	5.01

Source: Duke CGGC, based on NC-RETS

A number of utility-scale solar projects are proposed for the state. Currently, 377 facilities totaling 3,034 MW in nameplate capacity are in various stages of planning and development. It is uncertain how many of these projects will

Figure 8: Solar Facilities in North Carolina, 2014



Source : EIA, Electricity Generation and Consumption (EIA-906/920/923) be completed. The largest proposed plants are Innovative Solar's 80 MW facilities in Cumberland County and Anson County. Table 3 provides the largest proposed projects as of mid-December 2014.

3.2.1 Total Investment

The total investment in utility-scale solar projects across North Carolina is estimated at $2.0 billion.[40] The estimate includes all solar projects built from 2007 to mid-December 2014 and registered as operating with the North Carolina Renewable Energy Tracking System (NC-RETS). Table 4 lists the top-10 counties where solar investments have been made during that period. The full list is provided in Appendix C.

One of the remarkable aspects of the investment figures is the distribution across the Western, Central and Eastern regions and in both rural and urban areas of the state. Catawba, Robeson and Wayne counties, each rural, are the leading counties with utility-scale solar project investments. Western counties leading the list are Catawba and Cleveland. Central North Carolina counties hosting significant investments in solar power are Scotland, and Nash; Eastern counties are Robeson, Wayne, Beaufort, Duplin, Columbus, and Lenoir.

Table 3: Top Proposed Solar Plants, 2014

Facility	County	Capacity (MW)
Innovative Solar 46	Cumberland	80
Innovative Solar 37	Anson	80
Innovative Solar 42	Cumberland	75
Wiggins Mill Farm	Wilson	74

Note: Proposed plants are in various stages of planning and development. It is uncertain whether or when proposed plants will be completed or become operational.

Source: Duke CGGC, based on NCUC *Renewable Energy Facility Registrations*

Table 4: Solar investment by County, 2007-2014

County	Solar Investment ($)	Percent of NC Total Investment
Catawba	215,317,053	10.5%
Robeson	167,891,078	8.2%
Wayne	122,684,986	6.0%
Cleveland	99,437,456	4.9%
Beaufort	90,375,019	4.4%
Duplin	71,647,591	3.5%
Nash	69,741,783	3.4%
Columbus	66,344,689	3.2%
Scotland	60,311,599	2.9%
Lenoir	59,436,323	2.9%
Subtotal	**1,023,187,577**	**50.0%**
Other counties	1,021,322,217	50.0%
Total	**2,044,509,794**	**100.0%**

Source: Duke CGGC, based on NC-RETS

Solar Power on North Carolina's Military Bases

The U.S. military is moving to install and utilize renewable energy at domestic and international bases in an attempt to reduce expenditures on fuel and decrease reliance on foreign energy. In 2012, the military spent over $20 billion on energy and consumed 5 billion gallons of fuel. To address their mammoth energy needs, the Army, Navy and Air Force have announced planned installations of 3GW worth of renewable energy by 2025 (SEIA 2013). As of 2013, North Carolina bases have 3.51 MW of installed solar capacity. FLS Energy recently installed a large thermal solar facility at Camp Lejeune, a 246-square-mile Navy base located in Onslow County. The 2,000 panels installed on the base power nearly 75% of its hot water needs.

NC Solar Capacity, by Service Branch

Branch	Installed Capacity (MW)
Navy	2.780
Army	0.731
Air Force	0.002

Source: NC Sustainability Center. For additional information, see SEIA 2013 "Enlisting the Sun" and the National Resource Defense Council's Renewable Energy and Defense Database (READ-Database).

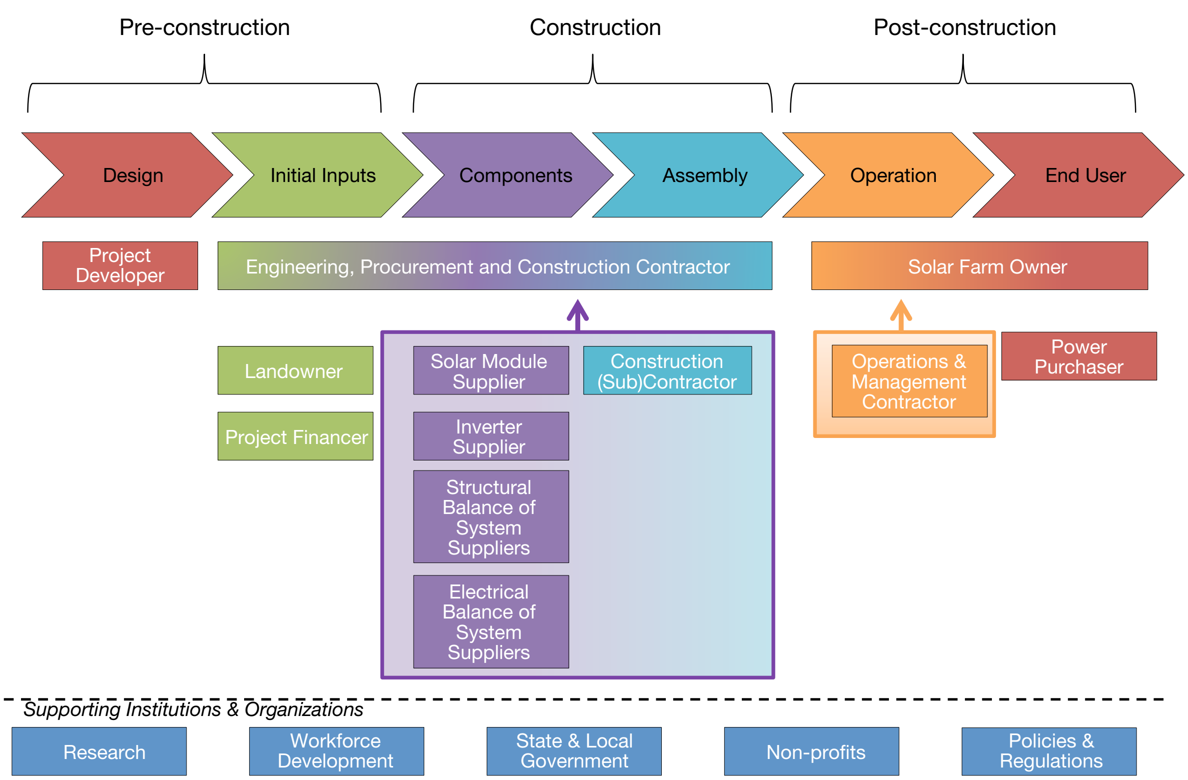
4. The Utility-Scale Solar PV Value Chain

4.1 Value Chain Overview

The utility-scale PV solar power value chain consists of key actors across pre-construction, construction, and post-construction phases. Figure 9 illustrates the utility-scale solar PV value chain.

North Carolina is home to over 450 companies that are involved in activities across the solar value chain and in supporting institutions such as research and advocacy. These companies support approximately 4,307 jobs across the utility-scale solar power value chain.[41] An overview of the actors in the value chain is provided in Table 5.

Figure 9: Utility-Scale Solar PV Value Chain



Source: Duke CGGC

Table 5: Value Chain Actors in the PV Solar Industry

Phase	Participant	Description
Pre-Construction	Project developer	The owner of the project when it is initiated. Usually responsible for initial design and permits.
	EPC contractor	The company primarily responsible for engineering, procurement and construction of the solar power plant.
	Landowner	The owner of the land on which the plant is located.
	Project finance	The financial partner providing any debt finance for the project (unless funded entirely through equity).
Construction	Construction (sub) contractor	The company responsible for plant construction. The construction firm may be the EPC contractor or a subcontractor of either the project developer or the EPC contractor.
	Component suppliers*	
	Solar module supplier	The manufacturer of the photovoltaic modules used in the power plant.
	Inverter supplier	The manufacturer of the power inverters used in the solar plant.
	Structural balance of system (BOS) suppliers	The manufacturers of the racking system, solar trackers and sensors (if installed) used in the plant.
	Electrical balance of system (BOS) suppliers	The manufacturers of cables, wires, switches, enclosures, fuses, meters and ground fault detectors used in the plant.
Post-Construction	Owner	The owner of the equity of the operating solar power plant. The owner is the beneficial recipient of the income generated by the solar power plant.
	O&M contractor	The organization primarily responsible for technical operation and maintenance (O&M) of the power plant after it is commissioned.
	Power purchaser	The utility, municipality or private commercial business purchasing the power output from the plant. Power interconnection agreements between the owner/project developer and the utility are a key bottleneck in the NC PV solar power value chain.
Supporting Organizations & Policies	Supporting organizations	The organizations facilitating information exchange, meetings and lobbying efforts on behalf of interested parties.
	Policies	The federal and state policies (e.g., tax credits, REPS, net metering rules) supporting the development of utility-scale solar.

* Component suppliers are selected by the EPC contractor, in consultation with the project developer.

Source: Compiled from various sources, including Rocky Mountain Institute (2010)[43] and WikiSolar[44]

Figure 10: Value Chain Actors Across Phases of Construction

Value Chain Actor	Pre-Construction	Construction	Post-Construction
Developer	✓	✓	
EPC Contractor	✓	✓	
Financing	✓	✓	✓
Component Suppliers		✓	✓
Owner			✓
O&M Contractor			✓
Power Purchaser	✓		✓

Source: Duke CGGC, based on company interviews

The value chain actors are active during different phases of the value chain. For example, project developers are primarily active during the pre-construction phase of the project, and they ensure that the design and permitting are in place for the EPC contractor to build the plant. The EPC contractor, in turn, is primarily active during the construction phase, and it ensures that the project is staffed with appropriate subcontractors and completed according to specifications. O&M contractors are active after the project is built, and they ensure the completion of the repair and maintenance required to operate the plant efficiently. Figure 10 illustrates the primary areas of activity for each value chain actor in the solar power value chain.

Many value chain actors have responsibilities across the project phases. For example, while the EPC contractor has the lead role during the construction phase, it also has an important role in the pre-construction phase in developing the site engineering and selecting subcontractors. Financing the project is not only a concern during the initial development phase but throughout the project as well, as financing partners cycle in and out and different types of financing are required (construction vs. equity investment). Similarly, the utility is primarily active in the post-construction phase as the power purchaser; however, the utility has an important role in the pre-construction negotiations with the project developer regarding interconnection and power purchasing agreements for the proposed plants. The timely processing of interconnection agreements was identified in our interviews as an important bottleneck in the further development of utility-scale solar power in North Carolina.

Having described the major phases and segments in the utility-scale solar PV value chain, we will now describe in more detail each segment and the actors active in North Carolina within each phase.

The Value Chain of a Project: The Ararat Rock Farm

The 4.4 MW Ararat Rock Solar Farm in Mount Airy spans across 25 acres of Surry County. Located next to the Ararat Rock Products quarry, the site generates approximately 6,288 MWh per year of electricity. The electricity is used at the quarry, with excess power sold to Duke Energy to place on the grid.

The developer and owner of the site is O2 Energies. National Renewable Energy Corporation (NARENCO), a Charlotte-based engineering, procurement and construction contractor (EPC), completed construction of the solar farm. The Ararat farm was built with more than 18,000 modules, purchased from REC Solar, that are manufactured with U.S.-produced silicon. In addition, Advanced Energy (AE), manufacturing in Colorado, supplied the inverters. Surrey Bank & Trust, a local financial institution, provided debt financing and insurance, making it one of the first local banks to participate in financing a large solar farm in its own community. O2 Energies worked with Surry Community College to provide workforce training for contractors, and NARENCO utilized local labor and vendors during the 16 weeks of construction. Sheep maintain the grass inside the fenced area and farmers work the land around the perimeter of the solar farm.

Source: NARENCO

4.2 Value Chain Segments and Actors

4.2.1 Pre-Construction Phase

The initial inputs necessary for utility-scale solar farms are land, permits and finance. The key actors securing these inputs in the pre-construction phase are the project developer, the finance partner and the EPC contractor.

4.2.1.1 Project Developer

The project developer, the owner of the project when it is initiated, is usually responsible for initial design and permits. The developer may or may not be the same entity as the EPC contractor, depending on whether it is a turnkey provider of utility-scale solar projects ("developer self-perform"). Table 6 lists the project developers in North Carolina with more than 5 MW of total capacity operating as of mid-December 2014.

4.2.1.2 EPC Contractor

The EPC contractor is the company primarily responsible for engineering, procurement and construction of the solar power plant. As mentioned above, the EPC contractor may also be the project developer, depending on whether the company is a turnkey provider of services. The largest EPC contractors active in North Carolina in the utility-scale solar sector are listed in Table 7.

Table 6: Top Project Developers Active in North Carolina, by Installed Capacity

Developer	Total MW	Headquarters	Employees	2013 Revenue ($M)
Strata Solar	271	Chapel Hill, NC	80	97.6
O2 Energies	32	Cornelius, NC	10	NA
Community Energy Inc. (CEI) (2)	28	Radnor, PA	40	4.6
SunPower Corporation	26	San Jose, CA	6,320	2507.2
Nationwide Renewable Energies Co (Narenco)	25	Charlotte, NC	15	NA
HelioSage	20	Charlottesville, VA	8	1.5
Apple, Inc.	19	Cupertino, CA	92,600	182,795
Sunlight Partners (2)	17	Mesa, AZ	2	.2
FLS Energy	11	Asheville, NC	150	150
Fresh Air Energy (Ecoplexus)	15	San Francisco, CA	4	5.4
SunEnergy1	14	Mooresville, NC	6	1.1
Duke Energy Renewables*	12	Charlotte, NC	27,948	24,598
Sustainable Energy Solutions	10	Northborough, MA	4	0.9
Argand Energy	9	Charlotte, NC	11	2.3
Carolina Solar Energy	5	Durham, NC	5	1.3

Note: Total MW based on NC-RETS.

*Data for Duke Energy Renewables and Duke Energy Carolina are for Duke Energy. *Duke Energy reports to the author that its operating installed capacity is 45 MW (see link).[45] The discrepancy is likely a reporting lag in the underlying source (NC-RETS). NA = not available.

Source: Duke CGGC; employees and revenue from OneSource, unless (2) Mergent Intellect

Table 7: Top EPC Contractors Active in North Carolina

Developer	Headquarters	Employees	2013 Revenue ($M)
Baker Renewable Energy	Raleigh, NC	15	NA
Carolina Solar Energy	Durham, NC	5	1.3
Entropy/Argand Energy	Charlotte, NC	11	2.3
ESA Renewables	Lake Mary, FL	9	NA
First Solar	Tempe, AZ	4,850	3,309.0
FLS Energy	Asheville, NC	78	39.1
Gerlicher-M&W	Springfield, NJ	20	3.0
Green State Power	Greensboro, NC	5	0.9
Innovative Solar	Fletcher, NC	3	0.6
National Renewable Energy Corporation (NARENCO)	Charlotte, NC	15	NA
O2 Energies	Cornelius, NC	4	0.3
PowerSecure/Southern Energy Management	Morrisville, NC	100	19.7
Strata Solar	Chapel Hill, NC	80	97.6
SunEdison	St. Peters, MO	300	25.2
SunEnergy1	Mooresville, NC	6	1.1

Note: NA = not available.

Source: CGGC; sales and employment from OneSource

4.2.1.3 Landowner

The landowner is the owner of the land on which the plant is located. Land selection criteria include access to a utility substation for interconnection, the price of the land, insolation, and general suitability for constructing a solar farm such as levelness of the land and soil quality. Land is normally leased to solar developers for periods of 20-30 years, but in some cases the owner of the solar farm will also own the land. Once a site is selected, permits are required from the local government for land use dedicated to solar farms.

4.2.1.4 Project Finance

Project finance refers to the financial partner providing debt or equity to complete a project. Financing is a crucial input for utility-scale solar projects. In this section, we review the major finance structures, sources of investment, and actors in North Carolina providing project finance for utility-scale solar.

4.2.1.4.1 Finance Structures

The finance structures for solar projects are based on the projected cash flow and other financial benefits (tax credits and depreciation) of the project. Utility-scale solar finance structures are typically of three types: (1) single owner (also known as "balance sheet finance"); (2) partnership flip (all-equity and leveraged types); and (3) leases (sale-leaseback and inverted lease). Different types of financing structures are not unheard of, as the selection of the structure can depend on many factors, including general investment conditions, the cost of capital, and the risk appetite of the developer and investor. Here we summarize the most common structures.[45]

Single-Owner Finance

Single-owner (balance sheet) finance occurs when the developer of the project invests directly into the project using its balance sheet, instead of relying project finance. Both utilities and private developers might use balance sheet finance.

Utility-owned solar projects allow the utility to diversify its electric power generation portfolio, to meet its renewable energy portfolio targets, and to exercise a high level of control over project siting and position in the electric grid. In addition, directly investing in solar projects has become more financially attractive due to the ability of utilities to access (until 2016) the 30% investment tax credit available through the Emergency Economic Stabilization Act in 2008.[46] Utilities can invest in a solar project through *direct finance, developer subsidiaries/ affiliates, ratepayer funding, shareholder funding, or utility prepay.*

- *Direct finance* occurs when the investor-owned utility (IOU) finances, owns and operates the solar plant. Utilities are particularly well positioned to access the capital needed to build solar projects because they are considered stable, creditworthy entities, and as a result they can attract capital at favorable interest rates even during tight credit markets. An example of direct finance is New Jersey's Public Service Electric and Gas Company (PSE&G), which in July 2009 received permission to use $515 million to install, own and operate 80MW of solar. The "Solar4All" program is anticipated to double the amount of solar in New Jersey.
- *Developer subsidiaries* are a second way utilities can invest in solar projects. Several major utilities, such as Duke Energy, San Diego Gas & Electric and NextEra, use development arms active in the market to install solar and renewable energy projects. For example, Duke Energy Generation Services, the unregulated developer subsidiary of Duke Energy, financed a 14.4 MW facility in Texas using balance sheet capital.[47]
- *Ratepayer funds* also can be used to support investment. For example, PG&E and SoCal Edison participate in California's Solar Power Initiative, in which solar power investments are recovered through the utility's base rate

Common Financial Structures in Utility-Scale Solar

Three finance structures are common in utility-scale solar: (1) single owner or "balance sheet finance" (2) partnership flips and (3) leases.

Single-owner (balance sheet) finance occurs when the developer invests directly into the project using its own funds, instead of relying on project finance. Advantages of balance sheet finance include access to 100% of the tax credits and the simplicity of outright ownership.

The **partnership flip** is designed to provide a fixed rate of return to the investor for a negotiated number of years, after which the cash flow and tax benefits revert (or flip) to the project developer. Partnership flips are a well understood financial structure in renewable energy. The tax equity investor realizes a reasonable return, and the developer accesses project financing at a reasonable cost.

Leases commonly used in the U.S. solar industry are the sale-leaseback and the inverted lease. In the sale-leaseback, the developer sells a completed system to a tax equity investor, who leases the system back to the developer while arranging a power purchase agreement with the power purchaser. In the inverted lease, the developer and tax equity investor fund a "master tenant" with a 1% investment by the developer and a 99% investment by the investor, in return for tax credits at the invested amount.

Details about the key advantages and disadvantages of each financial structure are discussed in the main body of the report.

and allowed to earn the company's weighted cost of capital.[48]

- *Shareholder funds* can be used to invest in private developers. For example, subsidiaries of PG&E invested tax equity in SolarCity and SunRun, enabling those companies to develop residential and commercial solar. The funds invested were shareholder funds that modified the dividends paid to shareholders but were not recoverable by ratepayers or incorporated into the rates charged by the utilities.[49]
- *Utility prepay (hybrid financing)* has been used by municipally owned utilities to take advantage of their low cost of capital and to receive the federal investment tax credit. In this structure, the utility will prepay for the energy delivered by a project under contract; the developer receives a lump sum payment, which it can use for a variety of purposes including construction financing. To finance the project, utilities can float bonds on their balance sheet. Although utility prepay is not currently used outside of municipal utilities, NREL considers it to be beneficial for solar projects, since the structure takes advantage of the low cost of debt for utilities and the federal tax credits associated with private project ownership.[50]

Private developer solar projects can be used to recapitalize the developer's balance sheet by selling an equity or debt position in projects, thus allowing the developer to commission more projects. The specific forms of partnership flips and leases discussed below are project financing mechanisms used by private project developers to increase the number and scale of projects beyond what they could afford using their balance sheet alone.

Partnership Flips

Partnership flips occur when a project developer partners with a tax equity investor to maximize the project's tax benefits.[51] Tax equity investors are investors who can use the tax benefits made available by state and federal investment tax credits (ITC) and accelerated depreciation schedules. The partnership flip financial structure is designed to provide a fixed rate of return for a negotiated number of years (typically 7-9%

after-tax internal rate of return (IRR) for 6-9 years), after which the cash flow and tax benefits revert (or "flip") to the project developer. The partnership agreement negotiated between the tax equity investor and the developer defines the terms of the initial investment by equity partners and the pre- and post-flip distribution of cash and tax benefits. The partnership has to be in place before the plant is placed into service.

Various forms of partnership flips exist, including the yield-based flip (based on the achievement of defined asset performance), the fixed flip (based on a fixed term regardless of performance), and the debt-based flip (in which the tax equity investor borrows part of the investment from a third party). The partnership flip is a well-understood financial structure in renewable energy markets, as it has been used for many years in wind energy. Advantages are that the tax equity investor realizes a reasonable return and the developer accesses project financing at a reasonable cost; project risk is reduced, as underperformance of the asset typically results only in a delay of the flip. Disadvantages are that the developer has to invest some of its own capital, which it may not have or want to use; less than 100% of the tax benefits are transferred to the equity investor, which may not be efficient if the developer is unable to participate in the ITC or accelerated depreciation; and tax benefits are based on the developer's cost, which may be less than the fair market value of the asset, thus reducing the benefits to both the tax equity investor and the developer.

Leases

Two types of leases are commonly used in the U.S. solar industry: the sale-leaseback and the inverted lease. In the *sale-leaseback,* the developer sells a completed system to a tax equity investor. At the same time, the tax equity investor leases the system back to the developer, who then arranges a power purchase agreement with the power purchaser. The PPA, in turn, is the primary revenue stream used to pay the lease payments to the tax equity investor. The advantages of the sale-leaseback are that it is a very simple financial structure; the tax equity investor receives 100% of the tax benefits; no financing capital is required from the developer; the financial structure can be put in place up to 90 days after the assets are in service; and the cost basis for tax benefits is the agreed price between the developer and the investor, which may be higher than the developer's cost. The disadvantages of the sale leaseback are that the cost of capital from tax equity investors may be higher than what the developer would incur using its own capital, even in part, to finance a project; the developer must make fixed rent payments, and these may be difficult to meet if the asset underperforms; and, if the developer wants to own the asset in the long term, it has to buy it back at the fair market value at the end of the lease, which must be 20% of the initial value.

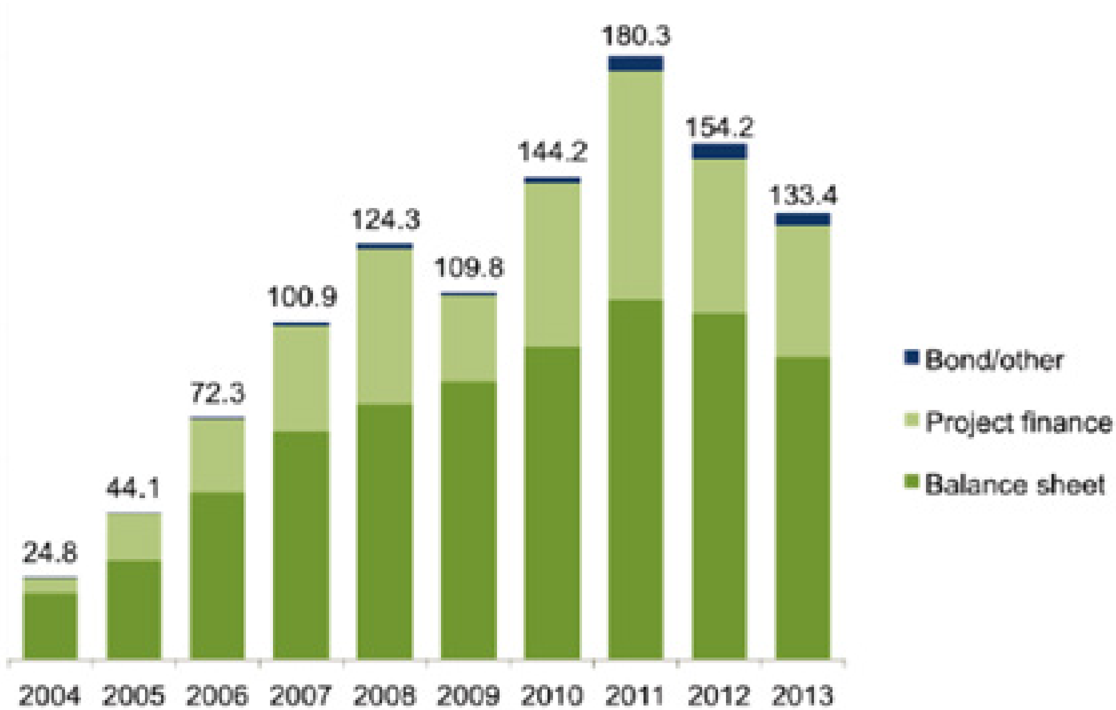
In the *inverted lease*, also known as a lease pass-through or master-tenant lease, the developer and tax equity investor fund a "master tenant" with a 1% investment by the developer and a 99% investment by the investor. In return, the developer receives 1% of the tax credit and the investor receives 99% of the tax credit. In addition, the developer and master tenant (99% owned by the investor) create an "owner/lessor" - of which 51% is typically owned by the developer- to own and lease the system to the master tenant. This arrangement allows the developer and tax equity investor to claim depreciation benefits in proportion to their ownership. The master tenant sub-leases the asset to the power purchaser, who makes lease payments to the master tenant. The master tenant makes lease payments to the owner/lessor. After the lease is completed, typically after 6-15 years, the developer takes back the project without any additional costs. The advantages of the inverted lease are that it allows an easy exit for the investor after the lease is completed; the tax credit is based on fair market value (appraised value) rather than the developer's cost, an arrangement that is good for the investor if the developer's cost is below industry averages; and depreciation is split from the tax credit, allowing the developer and investor to maximize benefits from these two tax streams. Disadvantages are that the investor/lessee has to make fixed payments to the developer/lessor regardless of the performance of the asset, and the Internal Revenue Service gives heightened scrutiny to inverted leases because the structure is susceptible to inflated fair market valuations.

4.2.1.4.2 Sources of Investment

Utility-scale solar projects are financed by a variety of actors. Globally, the largest proportion of asset financing of new investments in renewable energy comes from the balance sheet of the company (the shares were 81% in 2004 and 60% in 2011).[52] Project financing makes up most of the remaining 19-40% (see Figure 11).

Finance partners for utility-scale solar in the United States have typically been tax equity investors, equity investors and debt providers (see Table 8 for a summary). *Tax equity investors* are commercial banks, institutional investors, utilities and large corporations that can use the investment tax credit to offset tax liabilities.[53] At the national level, commercial banks active in utility-scale solar project financing are Bank of America, Citibank and Credit Suisse for large projects, and US Bancorp/US Bank, Wells Fargo and Union Bank for midsize projects.[54] Goldman Sachs, Morgan Stanley, JPMorgan and Bank of America's Merrill Lynch are investment banks active in utility-scale solar projects. Institutional investors active in utility-scale solar

Figure 11: Assets Financing New Investment in Renewable Energy ($B), 2004-2013



Source: Bloomberg, *New Energy Finance*, 2013 are MetLife Private Capital Investors, CalPERS (the California state employees' pension plan), and Potomac Energy Fund (a private equity fund that manages pension fund investments of trade unions such as the International Brotherhood of Electrical Workers. Utilities include the development arms of large utilities, including Duke Energy, San Diego Gas & Electric, NextEra and Washington Gas Holdings. Google is the most active corporate actor in utility-scale finance. Appendix B provides additional information on renewable energy investors active in the United States.

Equity investors are hedge funds and other institutional actors that have a stake in the company developing projects. York Capital Management and New Energy Capital are companies owning part or all of major developers in North Carolina.[55] U.S.-based venture capital and private equity (VC/PE) have generally reduced their investments in solar. In 2013 VC/PE investments declined 62% from the previous year.[56] VantagePoint Capital Partners abandoned fundraising in 2013 for a $1.25 billion clean technology fund it had launched in 2010 due to lack of interest. Others have reduced their exposure, including Kleiner Perkins Caufield & Byers, Draper Fisher Jurvetson, Mohr Davidow, NEA and Silver Lake. Interestingly, the CalPERS clean energy fund created in 2007, an early leader in this space, reduced its investments because of 10% losses over consecutive years.[57] Our interviews with utility-scale solar power developers in North Carolina indicate that VC/PE generally is not a good match for utility-scale PV solar due to the high returns on investment expected by these finance partners, typically in the double digits per year rather than the 7-9% IRR of a typical utility-scale solar project.[58]

Lenders provide construction financing and/or permanent debt for projects. Commercial banks in North Carolina that have provided funding for utility-scale solar are Wells Fargo, Fifth Third Bank and NC Bank. In addition, Seminole Financial Services and MP2 Capital have provided construction financing for projects in North Carolina. Community banks and credit unions in North Carolina have not had a big presence in utility-scale solar, largely because the capital investment required generally is too large for smaller banks. An exception is Surry Bank & Trust, which helped develop the Ararat Solar Farm in Mt. Airy, North Carolina (see *The Value Chain of a Project: The Ararat Rock Farm*, page 18).

Table 8: Investor Categories and Representative Companies Investing in Utility-Scale Solar

Investor Categories	Sample Companies
Commercial Banks	Bank of America
	Citibank
	Credit Suisse
	U.S. Bancorp
	Wells Fargo
Investment Banks	Goldman Sachs
	JPMorgan
	Merrill Lynch (BofA)
	Morgan Stanley
Institutional investors	MetLife
	CalPERS
	MP2 Capital
	Potomac Energy
Utilities	Duke
	SDG&E
	NextEra
	Washington Gas
Corporations	Google
Venture Capital/Private Equity	HighStar Capital
REITs	Hannon Armstrong Sustainable Infrastructure Capital
YieldCos	NRG Yield
	SunEdison
Crowdfunding	Mosaic

Source: Duke CGGC, based on Lutton 2013.

New investment entities and funding models are entering the utility-scale solar market. Securitizations, master limited partnerships (MLPs), real estate investment trusts (REITs), yield companies (YieldCos) and crowd funding are existing or potential new entrants into the solar market. For example, SolarCity, a rooftop solar developer, has created securitization through solar asset-backed securities; it raised about$ 55 million in bonds in late 2013 with plans for $200 million more, depending on the response in the market.[59] The asset-backed securities are funded from purchase power agreements and solar leases from existing customers. This model, although currently only used by SolarCity, could be adopted by utility-scale solar developers and owners for project financing. However, given the sunset of the 30% federal investment tax credit in 2016 and issues with mortgage securitizations arising out of the subprime lending crises, securitization is not as likely to be a dominant funding model. Other forms of funding could provide greater impact. MLPs have great potential to raise money for the solar industry. Although currently only available to the oil and gas industry, which has used MLPs to raise $84 billion for shale gas investments at an average cost of capital between 5.5% to 6%, the financing structure could be used to attract financing for renewables in general and utility-scale solar in particular, with legal modifications. The MLP legal modifications that would be required to allow parity among energy sources would have to overcome objections from the Treasury, which perceives MLPs as a tax shelter. But advocates say that if MLPs are allowed to exist, they should be available to all fuel sources.[60]

REITs have entered the market for renewables. REITs help developers convert assets into cash, and they create a liquid secondary market for renewable power projects that offer tax advantages. Hannon Armstrong Sustainable Infrastructure Capital invested $35 million in MidAmerican's Solar Project as part of its distributed energy generation portfolio, planned at $2 billion and yielding about 7% to its investors. While Hannon Armstrong was successful in converting itself from a renewable energy financing company into a REIT in April 2013, the regulatory status of REITs entering the renewable industry remains uncertain. The IRS has not made an administrative ruling to allow inclusion of renewable power assets in REITs, and congressional approval may be required.[61]

Yield companies (YieldCos) are an innovative financing vehicle that passes on a high share of earnings to shareholders. YieldCos enable developers to shift renewable power generation to a pure-play dividend-oriented company and provide stable, long-term cash flows.[62] In 2013, NRG Energy developed a tradable, dividend-producing security (NRG Yield) that includes both utility-scale and rooftop solar projects.[63] NRG Yield, with 1.3GW of rated generation (including solar and wind), became the first pure-play power YieldCo to execute an initial public offering on a U.S. exchange; it raised $431 million in July 2013. SunEdison raised over $530 million in the initial public offering of its yieldco TerraForm Power in late July 2014.[64]

Crowdfunding allows small companies and startups to raise capital from many small investors in return for an equity stake, structured payments and/or products. In early 2014, Mosaic, an online company based in the United States, began financing more than $5 million of solar projects by allowing individuals to make small investments in specific projects.[65] Mosaic provides yields of 5.5-7%, and has raised $5.6 million for solar projects since it opened its online platform in January 2013.[66] Nine institutional projects in North Carolina are currently partially funded by Mosaic investors.[67]

4.2.1.4.3 North Carolina Investors

The North Carolina Department of Revenue (NCDOR) compiles annual lists of state incentive recipients by amount of spending and amount of credits taken. Table 9 lists the major tax entities (company and individual) receiving credits under Article 3B, Business and Energy Credits for Investing in Renewable Energy Property. Since the majority of renewable energy investment in North Carolina is solar related, the lists provide detailed insights into the most important investors for solar energy in the state. A recently completed economic impact assessment by RTI estimates that $1.93 has been returned to state and local governments for each dollar spent on the Renewable Energy Investment Tax Credit.[68]

4.2.2 Construction Phase

The components required for utility-scale solar farms are solar modules, inverters, and structural and electrical balance-of-system (BOS) components. Specialized construction firms, EPC contractors or turnkey developers may provide the installation of the solar farms. We provide an overview of the key components and companies supplying and installing components to North Carolina utility-scale solar farms in this section. Section 4.2.2.1 discusses component suppliers, and Section 4.2.2.2 discusses construction contractors and installers.

4.2.2.1 Component Suppliers

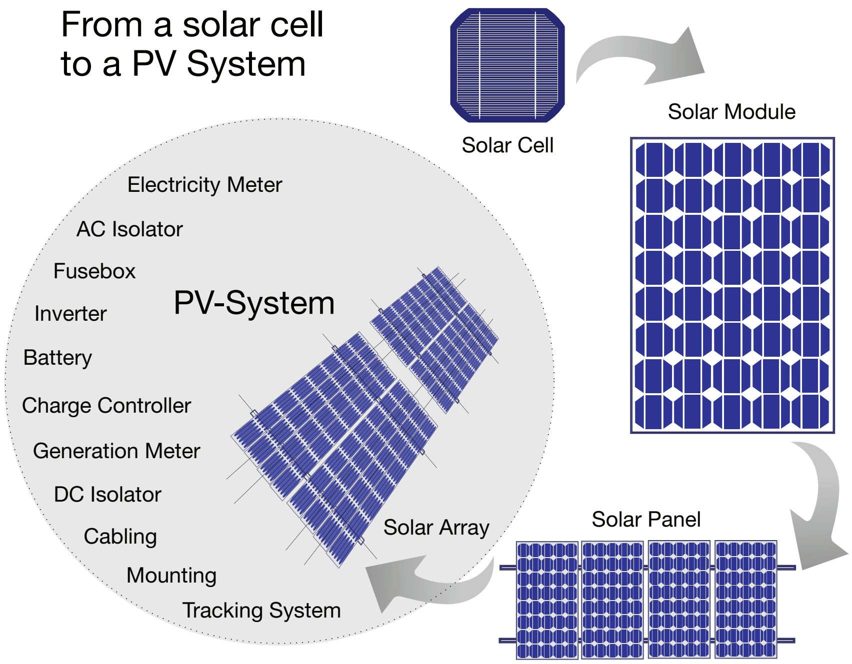
Solar Modules: The principal component necessary for solar farms are PV cells. These cells are grouped together into modules and panels, which are installed into the farm (see Figure 12).

Table 9: NC Renewable Energy Tax-Related Spending (<$10M) and Credits Taken, 2010-2013

Name	Spending	Credits Taken
Blue Cross and Blue Shield of NC	150,812,092	12,696,204
Metropolitan Life Insurance Co.	51,354,048	11,890,110
Bank of America Corp. and subs	43,379,764	7,969,794
Northwestern Mutual Life Ins. Co.	32,869,477	2,428,563
Wilhelm, Markus F. (Strata)	31,887,707	2,207,565
Tucker, Robert B.	27,339,369	1,880,220
United Services Automobile Association	26,909,244	4,895,039
BB&T Corporation	26,230,345	4,405,172
Habul, Kenny C. (SunEnergy1)	23,180,524	1,394,672
US Bank National Association	16,025,696	961,158
Duke Energy Corporation	15,242,000	2,491,129
Nationwide Mutual Fire Insurance Co.	15,226,287	1,065,839
FLS Solar	12,961,060	1,425,278
Waste Industries USA Inc.	12,021,185	105,586
Genworth Life Insurance Co.	10,565,186	780,609
Watts, Claudius E.	10,333,560	260,855
Others	*139,204,580*	*15,890,768*
Total	**645,542,124**	**72,748,561**

Source: NC Department of Revenue

Figure 12: A Solar PV System



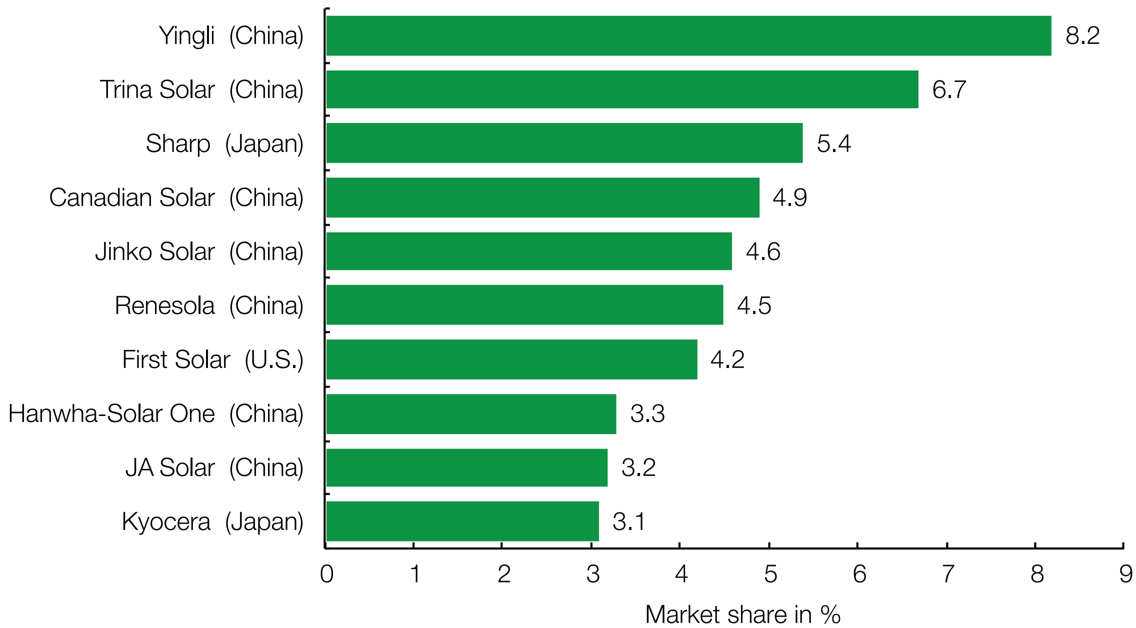
Source: Wikipedia Commons

The average number of panels and the capacity of utility-grade solar farms vary by location with the amount of sunlight, amount of electricity consumption, and temperature/climate all impacting the amount of PV panels needed. On average, each megawatt of solar energy in North Carolina is capable of powering 95 homes.

PV panels, mounted on racks made of steel or aluminum, are connected via copper wires into an inverter that converts the energy generated from DC into the AC energy required for the grid. The mounts are sourced from a variety of locations, with some firms, such as German-owned Schletter or Daetwyler Clean Energy, a subsidiary of Swiss-based Däetwyler, having manufacturing facilities in North Carolina. The AC electricity then flows to a transformer. Solar power generally produces electricity at tens to hundreds of thousands of volts, while solar inverters normally have an output of a few hundred volts. To prevent issues, currents pass through the transformer before being incorporated into the main electricity grid. A meter helps to track the amount of electricity transferred.

In some cases, utility-scale solar farms are used for large commercial purposes, such as shopping centers, factories or hospitals. The Apple Solar Farm near Maiden, N.C. is an example of such a plant. These plants may install batteries to store unused energy during peak times, and they may also incorporate bi-directional meters that credit an establishment when it transfers electricity to the main grid and records energy use during times the establishment draws from the grid.

Figure 13: Major PV Solar Cell Manufacturers & Market Share



Source: Bloomberg, *New Energy Finance,* April 2014

Major solar PV module manufacturers (see Figure 13) are Yingli (China), Trina Solar (China), Canadian Solar (Canada), Jinko Solar (China), RenaSolar (China), Sharp Solar (Japan), First Solar (U.S.), Hanwha SolarOne (China), Kyocera (Japan) and JA Solar (China).

Major Inverter Suppliers: The inverter is a crucial subsystem, not just for converting DC to AC but also for "power tracking" to hold the solar arrays close to their peak power point. Inverter suppliers are national companies with national markets. The major national inverter suppliers are listed in Table 10.

Racking Systems: Racking systems are sourced from a variety of providers like USAracking, UniRac, Schletter, RBISolar and SunLink. Schletter has manufacturing facilities in North Carolina.[69]

Table 10: Major Inverter Suppliers

Rank	Name	# of Projects	Total MW
1	SMA	26	648
2	Power-One	15	373
3	SunGrow	21	359
4	Schneider Electric	11	286
5	Emerson	10	212

*Number of projects and MW reported as of 2013

Source: SolarWiki

Developers and EPCs tend to have preferred vendors with whom they conduct business over time and across multiple projects (representative North Carolina component suppliers are listed in Table 11). The company-level supply chains for developers and EPCs appear to be an open secret in the industry. For example, Strata uses SMA for

Table 11: Representative NC Component Suppliers for PV Systems

Company	Component	Headquarters (U.S.)	Employees	2013 Revenue ($M)
ABB Inc.	Inverter	Raleigh, NC	11,250	3,800
Advanced Digital Cable Inc.	Cables	Hayesville, NC	60	73.9
Armacell LLC	Foam	Mebane, NC	300	15.7
Camstar Systems Inc.	Software	Charlotte, NC	15	100
Daetwyler Clean Energy	PV modules and racks	Huntersville, NC	NA	NA
DuPont Photovoltaic	PV panels	Fayetteville, NC	150	324.6
Hawe Hydraulics	Hydraulic tracking	Charlotte, NC	NA	NA
InnoLas Inc.	Semiconductors	Pittsboro, NC	NA	NA
Jetion Solar (US)	PV modules	Charlotte, NC	5	6.1
Muratec	Semiconductors	Charlotte, NC	110	190
Pilkington North America	Glass PV coating	Toledo, Ohio	400	159
Sapa Extrusions	Mounting systems	Burlington, NC	100	39.2
SBM Solar LLC	Panels	Concord, NC	6	1.9
Schletter Inc.	PV racks	Shelby, NC	150	4.9
Semprius Inc.	PV modules	Durham, NC	20	0.8
Smarttech International LP	Replacement parts	Charlotte, NC	NA	NA
Technical Coating Int'l	Coating	Leland, NC	30	4
Torpedo Specialty Wire Inc.	Wire	Rocky Mount, NC	126	142.8
Wieland Electric Inc.	Cables	Bungalow, NC	NA	NA

Source: Duke CGGC; employees and sales from OneSource

inverters and Schletter and FirstSolar for racking. FLS uses Schletter and SBI for racking and the Horne Brothers for construction. Entropy uses Solectria for inverters, RBI for racking and Canadian Solar for panels. Gerlicher uses Horne Construction and SunSolar for construction, SMA and AdvancedEnergy for inverters, and RBI and Schletter for racking. The panel market is less relational and more price sensitive. Panels used in North Carolina utility-scale solar are manufactured by Yingli, Catrina, Ginko and Canadian Solar, among others. Ongoing tariff disputes between the United States and China affect the selection by solar developers and EPCs of cell technology and manufacturers.

4.2.2.2 Construction Contractors/Installers

The installation of utility-scale solar farms is completed by either the developer (known as "developer self-perform" (DSP)) or a construction contractor, who may either be an EPC or a subcontractor of either the developer or the EPC. DSPs active in North Carolina are Strata Solar, FLS, Entropy and SunEnergy 1. Many construction contractors keep specialized project managers as salaried personnel, while construction workers are hired by the firm or by a temporary personnel agency on an as-needed basis. As a result, full-time-equivalent construction positions are difficult to accurately estimate for the state. As a general

Table 12: Major Construction Contractors Active in North Carolina's Utility-Scale Solar Power Value Chain

Company	Headquarters (US)	Employees	2013 Revenue ($M)
Advance Construction Enterprises (1)	Advance, NC	3	0.23
Bonville Construction DBA Sandhills Energy (2)	Pinehurst, NC	5	3.2
FirstSolar (2)	Tempe, AZ	4,850	3,309
Horne Brothers (2)	Fayetteville, NC	40	18.9
MB Haynes	Asheville, NC	145	40
Native Solar	Pembroke, NC	NA	NA
Phoenix Solar (2)	San Ramon, CA	187	114
Pike Energy Solutions (1)	Pittsburgh, PA	4,143	594
Pure Power Contractors Inc.	Waxhall, NC	4	1.0
Renewable Energy Contractors	Blowing Rock, NC	NA	NA
Solar Energy USA (1)	Alpharetta, GA	10	1.1
Solargenix (2)	Sanford, NC	14	3.7
Vaughn Industries	Carey, Ohio	525	130
Watson Electrical (1)	Wilson, NC	50	97.4
White Electrical Construction Company (1)	Atlanta, GA	300	37.4

Source: (1) Mergent Intellect; (2) ONESource; (others) company contact

rule of thumb, an average 5MW solar project takes about 12-16 weeks to complete and can involve 30-50 construction workers, electricians and installers. The major construction firms installing utility-scale solar in North Carolina are listed in Table 12.

4.2.3 Post-Construction

4.2.3.1 Power Purchasers

Utilities and large commercial/industrial organizations purchase and use the energy generated from utility-scale solar facilities. Utility companies such as Duke Energy have subsidiaries that invest and develop solar farms to add to their electric power generation mix. With legislation requiring that 12.5% of all energy come from renewable sources by 2021, the firm is increasing investments in solar farms. In September 2014 Duke Energy announced a $500 million investment in solar involving construction of three large solar farms, including one in Duplin County that will cover one square mile and have the capacity to generate 100 MW of power annually. If built, it will be the largest farm on the East Coast.

Table 13: North Carolina Solar Power Purchasers

Power Purchaser	Nameplate Capacity (MW)
Progress Energy	323
Duke Energy	158
North Carolina Eastern Municipal Power Agency	40
Duke Energy Carolinas	25
Duke Energy Progress	17
Dominion NC Power	5
Edgecombe EMC	5
Energy United Electric Membership Corporation	1
North Carolina Municipal Power Agency	1
Total	**573**

Note: Progress Energy, Duke Energy and Duke Energy Carolinas have merged to become Duke Energy Progress. Name in table reflects information reported to the NCUC.

Source: Duke CGGC, based on NCUC-RETS

Large organizations are also using utility-level solar farms to supply their energy needs. Businesses such as Apple have installed solar plants in the state; Apple's two operating farms contribute 20 MW to the state's energy grid, and in June 2014 the company announced plans to install a third solar farm in Claremont.[70] The National Gypsum plant in Mount Holly installed its solar farm on the building's 145,000 square-foot roof, taking advantage of the heavy sunlight to generate 1.2 MW annually that the company uses and also sells to Duke Energy.[71]

4.2.3.2 Operations and Facilities Maintenance (O&M Suppliers)

Turnkey developers like Strata Solar, which develop, finance and construct solar plants and hold the properties, often keep operations and facilities maintenance functions in house. Individual plants may subcontract with a local electrician for maintenance. Companies outside North Carolina providing O&M services are SunEdison and FirstSolar.

4.2.4 Supporting Policies and Organizations

This section highlights federal and state-level policies and organizations supporting the development of utility-scale solar power in North Carolina. The discussion on policies is divided into federal investment incentives and trade policy, and North Carolina policies in place to encourage investment in utility-scale solar. We close with a list of supporting organizations active in the utility-scale PV solar value chain.

4.2.4.1 Policies

Federal Tax and Energy Policies

The U.S. government has various mechanisms in place to encourage efforts that contribute to solar power investments.

- The **Energy Tax Act of 1978** established the federal Investment Tax Credit (ITC) to aid the financing and build-out of renewable energy projects. It allowed the cost of 10% of eligible solar properties to be deducted from taxable income. The **Energy Policy Act of 2005** increased the ITC from 10% to 30% for eligible solar properties. The **Emergency Economic Stabilization Act of 2008** extended the solar ITC at the 30% rate to 2016 and expanded eligibility to investor-owned public utilities; public utilities were not eligible for the ITC prior to the act. After 2016, unless renewed at the higher rate, the ITC will revert to 10% for eligible properties.
- The **Modified Accelerated Cost Recovery System** (MACRS) enables commercial and industrial owners to accelerate the depreciation of renewable energy equipment. Accelerated depreciation can be taken over five years of project life, or six tax years.

Depreciation is calculated on 85% of the cost of eligible solar property.

- The **Public Utilities Regulatory Policies Act (PURPA) of 1978** requires public utilities to purchase distributed generation below 80MW at the avoided cost rate, as determined by state regulators. PURPA requirements have been important in stimulating the development of distributed power generation in the United States.

Federal Trade Policies

U.S. trade policies have a major effect on solar panel manufacturers both domestically and abroad. The Commerce Department first implemented protective tariffs on Chinese crystalline silicon photovoltaic cells in a two-step process in 2012. In response to a 2011 complaint lodged by the American subsidiary of SolarWorld AG (based in Germany) and six U.S. companies, the agency ruled in May 2012 that Chinese companies were unfairly benefiting from government subsidies. The Commerce Department set initial punitive tariffs of 31% on 59 Chinese companies[72] including Yingli Green Energy, LDK Solar, Canadian Solar, Hanwha Solar One, JA Solar Holding and Jinko Solar.

In October 2012, the Commerce Department issued what it described as its "affirmative final decision" on the case.[73] The department determined that Chinese businesses had received subsidies of between 14.7% and 15.9% and had sold solar cells in the United States at dumping margins of 18-250%.[74] Dumping margins are the difference between the price (or cost) in the foreign market and the price in the U.S. market.[75] The specific products that Chinese firms were manufacturing were equipment crystalline silicon photovoltaic cells as well as modules, laminates and panels consisting of crystalline silicon photovoltaic cells. The final tariffs implemented against Chinese firms ranged from 24% to 36%, with Suntech, one of the largest panel makers, receiving the highest individual tariff.[76]

At the time, industry observers predicted that the Commerce Department's ruling would have only minimal repercussions for the market for solar panels.[77] That analysis proved to be accurate, although for reasons not completely anticipated at the time of the decision. After criticizing the United States as being overly protectionist, Chinese solar companies exploited a loophole through which they could assembly panels from cells produced abroad, especially Taiwan, and avoid the duties even if the cells were produced from smaller parts (ingots and wafers) made in China.[78]

In an effort to redress this apparent oversight, SolarWorld AG filed a grievance with the Commerce Department. In the summer of 2014, the agency offered two separate rulings that imposed new tariffs on Chinese companies. In June, the Commerce Department imposed duties of 19-35% on some Chinese firms; in July, it imposed additional tariffs of 10-55%. The immediate outcome was that panel prices increased in one month by roughly 10%, impairing the demand for products made by low-cost manufacturers such as Yingli and Suntech but boosting sales by companies that had previously been undercut by their Chinese competitors.[79]

Questions remain about the regulatory terrain for the industry. In July 2014, the World Trade Organization (WTO) ruled that the Commerce Department's 2012 judgment against China violated international trade rules. Chinese officials, presumably believing that the decision did not go far enough, filed an appeal in August 2014. Even without the appeal, industry stakeholders predicted that the WTO decision would not have a strong effect since it would not reduce anti-subsidy tariffs by a large amount; many have argued that the clearest path toward a stable regulatory environment is negotiating an agreement between SolarWorld AG and its competitors both in the United States and China and India that would eliminate or reduce duties.[80]

Blaming a "ministerial error," the Commerce Department reduced the tariffs being levied against solar products made in Taiwan in August 2014.[81] While the anti-dumping tariff on Taiwanese manufacturers such as Motech was reduced from 44.1% to 20.9%, industry analysts said they did not believe China would resume using Taiwanese suppliers. Chinese manufacturers of U.S.-bound modules had shifted to using Chinese companies almost exclusively, and paying the 2012 cell tariff, which was around 31%.[82] Conversations with solar developers in North Carolina indicate that the ongoing trade disputes and tariff levels affect their solar-panel purchasing decisions.

North Carolina Policies[83]

North Carolina has several policies in place supporting the development of solar power. Among these are:

- **Article 3B Renewable Energy Tax Credit (RETC):** The RETC legislation (G.S. 105-129.16A) allows the application of a 35% deduction of the cost of a renewable energy facility. The credit can be taken against the franchise tax, the income tax or, if the taxpayer is an insurance company, the gross premiums tax (G.S. 105-129.17(a)). It expires December 31, 2015.[84] North Carolina has had an RETC in place since 1977.[85] Past credits have ranged between 20% and 40%.[86]
- **Renewable Energy and Energy Efficiency Portfolio Standard (REPS):** REPS Legislation (G.S. 62-133.8) requires that investor-owned utilities derive 12.5% of all energy from renewable sources by 2021 (with annual interim targets, including 5% in 2015 and 10% in 2018). Municipally-owned utilities and cooperatives must achieve a 10% renewable target by 2018, with no additional requirement for 2021. Utilities can use energy efficiency gains to replace some renewable generation. Also known as Senate Bill 3, REPS received bipartisan support in 2013 in the face of repeal efforts because state legislators did not want to lose the economic development benefits of renewable energy.[87]
- **Interconnection Standards:** The NCUC adopted interconnection procedures in June 2008 that apply to the state's investor-owned utilities. These standards generally follow Federal Energy Regulatory Commission (FERC) standards.[88] North Carolina's standards include levels of interconnection review, with fast-track application available to generators smaller than 2 MW; systems larger than 2MW follow the "study process" in which the utility investigates and makes a determination about the adequacy of the proposed interconnection point for the qualifying facility.[89] North Carolina has adopted a standardized interconnection agreement that applies to all utilities. However, interconnection procedures are applicable only to public utilities, not municipally owned utilities and co-ops.[90] The timeliness of receiving approved interconnection agreements was repeatedly cited in our interviews as a key bottleneck in the pace of development in utility-scale solar.
- **Power Purchase Agreements (PPAs):** Solar projects at or below 5MW receive a standard power purchase agreement, which currently is at the avoided cost rate for 15 years. For solar projects above 5MW, PPAs are negotiated between the utility and the solar power project developer.
- **Net Metering:** The net metering policy allows the return of electricity generated from on-site distributed systems, such as solar panels, to the grid. Net metering energy credits are calculated at the retail rate. The statutory limit for net metering in North Carolina is 1MW,

and thus does not apply to the overwhelming majority of the plants in the utility-scale solar segment investigated in this report.

> *"We don't want an environment where we have incentives forever. But we need a clear path to allow the industry to adjust so that we're not in a position where it starts and stops in fits."*
>
> *– Erik Lensch, Entropy Solar*

Policies at both the federal and state level have been successful in encouraging the growth of utility-scale solar in North Carolina. Most notable among these are the ITC at the federal level and the REPS and RETC at the state level. Whether the ITC and RETC policies will be extended beyond their expiration dates of December 31, 2016 and December 31, 2015, respectively, is a source of concern in the North Carolina utility-scale solar industry. While solar developers generally recognize the need to be cost competitive with other electric power generation fuel sources, the abrupt ending of the federal and state tax credits will have effects in the industry that to some are unnecessarily shortsighted and harmful to the future of the industry in the state. "We don't want an environment where we have incentives forever," stated Erik Lensch of Entropy Solar Integrators. "But we need a clear path to allow the industry to adjust so that we're not in a position where it starts and stops in fits.…[T]he visibility on our runway is pretty short, and I don't want people to lose work because of an incentive structure that has changed overnight."

The solar developers and EPC contractors we spoke to recommend a phased approach to the reduction or elimination of the state-level tax credit. Two policy proposals supported in the developer community were a "continuance of construction" policy, where investments made prior to the current state-level deadline would receive the tax credit if the projects were completed within a reasonable six- or 12-month window. A second proposal is the "safe harbor provision," which would allow the state credit to be taken within an 18-month period (by the middle of 2017) if a portion of the project expenses were taken by the end of 2015. These policies would remove the current incentive for developers to get projects in under the December 31, 2015 deadline and reduce the logjam of projects waiting for interconnection approval.

Developers noted that without these modifications the surge of projects in 2015 will make an already-clogged approval system for interconnection agreements worse. As noted by IREC in its annual report on grid-connected PV solar, it is typical to see a surge of applications before the incentives deadline and then a drop-off in installations after the deadline has passed.[91] The average length for design, permitting, finance and construction for a 5MW utility-scale solar project in North Carolina is around a year to 18 months, particularly with the current backlog of interconnection agreements approaching 400 facilities.[92] The interconnection study requirement for projects greater than 2MW has overwhelmed the utilities, and turned a "pro forma" 45-day process into a 365-day process. The result is that developers don't know when projects will get approved because a determination has not been made by the utility that an adequate interconnection point exists. This uncertainty acts as a limit on the number of projects that will get built in North Carolina.

Without the available tax credits, institutional and tax equity investors will reduce their investments in new renewable energy projects.[93] The reduced availability of tax credits will likely have two effects. The first is market consolidation among independent solar developers, which may occur because institutional investors prefer companies that can survive the subsidy's elimination and remain able to manage long-term investments.[94] The second is the expansion into new markets by developers with the financial ability to capture profits through their economies of scale. Among the developers identified as having aggressive national geographic diversification strategies are Strata, SunEdison, Recurrent Energy, SunPower, NextEra Energy, Hecate Energy, Juwi Solar, Innovative Solar Systems and FirstWind Solar.[95]

A decline in investment by independent solar developers may benefit electric utilities. A report by the Lawrence Berkeley National Lab found that utilities and shareholders could see revenue declines as solar PV increases unless utilities invest in or finance solar projects themselves.[96] The report found that solar affects utility revenues in two ways: one is the faster reduction of sales than costs leading to a "revenue erosion effect." The second is the reduced need of regulated utilities to invest in future capital, thereby reducing future earnings from returns on equity. Thus, policies that have the effect of reducing the pool of non-utility-owned facilities improve the long-term financial standing of utilities and their ability to benefit stockholders.

4.2.4.2 Organizations

A number of educational and non-profit organizations provide supporting roles in the North Carolina utility-scale PV solar power value chain. Among them are:

North Carolina State University Clean Technology Center: Formerly the N.C. Solar Center, the Clean Technology Center develops technology and policy initiatives in solar and other clean energies for businesses, policy makers and other organizations. The center is a clearinghouse for energy programs, information, applied research, technical assistance and training. It is home to the national Database of State Incentives for Renewable Energy (DSIREUSA.org), and it is a national reference site for energy policies across the United States (http://nccleantech.ncsu.edu/).

University of North Carolina at Chapel Hill Energy Frontier Research Center for Solar Fuels (UNC EFRC): Funded by the U.S. Department of Energy, Office of Basic Energy Sciences, and established in 2009, the UNC EFRC's efforts range from basic research on fundamental processes to integrating components into sub-systems and sub-systems into prototypical devices. The primary target is dye sensitized photoelectrosynthesis cells (DSPEC) for solar fuels production. The research center, headquartered in Chapel Hill, is partnered with the University of Florida, the Georgia Institute of Technology and the University of Colorado at Boulder (http://www.efrc.unc.edu/).

Duke University Nicholas Institute for Environmental Policy Solutions: The Nicholas Institute conducts policy research on renewable energy issues (http://nicholasinstitute.duke.edu/). In addition, the **Nicholas School for the Environment** (http://nicholas.duke.edu/) conducts basic research on energy issues and educates undergraduate and graduate students about renewable energy, among other issues.

Duke University Energy Initiative: The Energy Initiative is focused on educating future leaders, conducting research, and engaging with business and policy decision makers to address three major energy challenges: meeting growing energy demand to support a competitive and prosperous economy, reducing the environmental footprint of energy and addressing energy security concerns (http://energy.duke.edu/initiative).

Appalachian State University Appalachian Energy Center: The Appalachian Energy Center conducts energy research and applied program activities in the areas of energy efficiency, renewable energy technologies, forecasting and modeling, economic development, and policy analysis in a multidisciplinary environment that leverages the expertise of faculty, staff and students from across the university as a resource for private industry, local, state and federal governments, and non-profits. (http://energy.appstate.edu/).

North Carolina A&T State University Center for Energy Research and Technology: CERT is an interdisciplinary energy research center created to foster collaborative research and development of new energy-related technologies. Grounded in engineering and built-environment sciences, the center focuses on basic and applied research; outreach and extension activities; and education relating to renewable energy, energy efficiency, alternative fuels and vehicle technologies, sustainable green building, and the environment (http://www-dev.ncat.edu/research/cert/index.html).

North Carolina Sustainable Energy Association: NCSEA is a 501(c)(3) non-profit organization dedicated to driving public policy and market development that creates clean energy jobs, economic opportunities and affordable energy (http://www.energync.org/).

Appendix

A. Report Methodology, Data Sources and Limitations

Methodology

We conducted the research for this report in four phases. In the first phase, we reviewed secondary source materials – press releases, industry publications and online sources – for information on the global, U.S., and North Carolina utility-scale solar PV industry. The purpose of this phase was to better understand the solar power industry, the market and technology trends affecting the adoption of the technology, and the actors in the production network of goods or services in North Carolina. In the second phase, we interviewed developers, EPC contractors, and structural/electrical balance-of-system providers in the solar industry to develop a preliminary understanding of the value chain. As a result of these interviews, we developed the solar PV value chain to organize our understanding of the industry.

In the third phase of research, we conducted additional interviews with lead and local firms, experts in technology and finance, and regulatory agencies. The objective of this phase was to better understand specific technical or regulatory aspects not fully apparent at the second stage, to identify additional companies in the value chain nodes, and to better understand the role of these companies in the production system. During this phase, our questions became specific and covered the full range of issues discussed in this report.

In the fourth phase of research, CGGC contacted individuals who are well informed about the industry and asked them to review the value chain and accompanying report. We requested that they provide comments and corrections of either fact or interpretation. Revisions to the report as a result of the external review process were made. Conducting value chain studies in this manner is time intensive, but provides a level of detail and understanding of industries not replicable by a review of only secondary source materials or a quantitative analysis of economic impacts. A bottom-up, ground-level perspective offers insights into markets, technology trends, and the effective role for government action that would be difficult to achieve using other methods.

Data Sources

We relied on reports and data from international agencies, official U.S. statistics and reports, the North Carolina Utilities Commission, the North Carolina Department of Revenue, company interviews, and widely recognized and reputable third-party publications in the renewable energy field. The specific reports and data used in the report are cited in the endnotes. While existing reports were important for understanding general trends in the industry, we found that our interviews with North Carolina companies provided a level of detail and perspective about regional dynamics that other sources could not provide. We appreciate the cooperation of the many companies we contacted for their information and perspective.

Report Limitations

Although the direct impact of utility-scale solar reported here is impressive, we believe that the economic impact in North Carolina is broader in many ways. We do not measure employment and sales resulting from changes in personal spending due to increased employment income and lease payments to landowners (induced effects); infrastructure improvements to the electrical grid in rural areas of the state; the development of unproductive or underutilized land; or the economic, environmental and social benefits of less-polluting electric power generation. Value chain assessments are useful tools for conveying to the public and policy makers the importance of industries to economic development and jobs in direct economic terms. Our hope is that in combination with formal economic impact modeling, such as those recently completed with respect to the North Carolina renewable energy industry,[97] the true effects of utility-scale solar can be measured and used to inform the ongoing public policy debate about the role of photovoltaic solar power in North Carolina's energy future.

B. Examples of Renewable Energy Tax Equity Investors, Debt Providers and Project Finance Providers

Tax Equity Investors

2007	2008	2009	2010
Bank of America	Bank of America	Bank of America	Bank of America
GE EFS	GE EFS	Citibank	Citibank
HSH Norbank	HSH Norbank	Credit Suisse	Credit Suisse
JP Morgan	JP Morgan	GE EFS	GE EFS
Key Bank	Key Bank	JP Morgan	Google
Morgan Stanley	Morgan Stanley	Key Bank	JP Morgan
New York Life	New York Life	Morgan Stanley	Key Bank
Northern Trust	Northern Trust	Northern Trust	MetLife
Union Bank	Sempra Energy	U.S. Bank	Morgan Stanley
Wells Fargo	Sun Trust	Union Bank	Northern Trust
ABN Amro	U.S. Bank	Wells Fargo	PG&E
AIG	Union Bank		PNC Bank
Citibank	Wells Fargo		Sun Trust
Fortis			U.S. Bank
John Hancock			Union Bank
Lehman Brothers			Wells Fargo
Merrill Lynch			
Northwestern Mutual			
Prudential			
Wachovia			

Source: Mintz Levin

Debt Providers to US Renewable Energy

2007	2008	2009	2010
Banco Santander	Banco Espirito Santo	Banco Espirito Santo	Banco Santander
Bayern LB	Banco Sabadekk	Banco Santander	Bank of Montreal
BBVA	BBVA	BNP Paribas	Barclays
Dexia	BTMU	BTMU	BBVA
Fortis	Calyon (Credit Agricole)	Calyon (Credit Agricole)	BTMU
HSH Nordbank	Citibank	CoBank	Caja Madrid
JP Morgan Chase	Dexia	Credit Suisse	Citibanl
Mizuho	HSH Nordbank	Dexia	Credit Agricole
Natixis	ING	Helaba	Credit Suisse
Nord LB	Lloyds TSB	HSH Nordbank	Deutche Bank
Prudential	Morgan Stanley	John Hancock	Dexia
RBS	Nord LB	Key Bank	Heleba
Union	Prudential	LBBW	ING
	RBS	Lloyds TSB	John Hancock
	Scotia Bank	Nord LB	Key Bank
	UniCredit	Prudential	LBBW
	Union Bank	RBS	Morgan Stanley
		Scotia Bank	Natixix
		UniCredit	Prudential
		Union Bank	Rabobank
		Societe Generale	RBS
		West LB	Societe Generale
			UniCredit
			Union Bank
			West LB

Source: Mintz Levin

Solar Finance Providers (Sample)

Commercial/Industrial/Utilities		
Tioga Energy	MMA Renewable Ventures	Chevron Energy Solution
MEMC	Green Rock Enregy	Regenesis
First Solar	Green Energy Finder	Solatage
Photon Energy Services	PVOne	EI Solutions
Solar Power Partners	SunPower Corp	Helop Micro Utility
Clean Source Power	Envision Solar	MP2 Capital
Recurrent Energy		

Source: Mintz Levin

C. North Carolina Utility-Scale Operating Facilities, by County

County	Estimated Cost	Nameplate Capacity (MW_{ac})
Alamance	11,122,359	4
Alexander	6,500,000	1
Beaufort	90,375,019	27
Bladen	39,525,339	10
Buncombe	22,078,000	6
Cabarrus	14,997,000	5
Caswell	20,000,000	5
Catawba	215,317,053	59
Chatham	22,500,000	5
Cleveland	99,437,456	24
Columbus	66,344,689	19
Craven	25,354,856	6
Cumberland	13,902,949	5
Davidson	7,378,738	2
Davie	36,333,434	10
Duplin	71,647,591	22
Durham	22,500,000	5
Edgecombe	12,816,155	3
Franklin	27,533,374	7
Gaston	5,455,484	1
Gilford	26,462,654	10
Granville	11,774,074	3
Greene	12,000,000	4
Guilford	17,790,555	5
Harnett	35,912,456	11
Haywood	4,516,129	1
Henderson	5,466,640	2
Hertford	21,082,109	5

County	Estimated Cost	Nameplate Capacity (MW_{ac})
Hoke	19,525,339	5
Johnston	20,000,000	5
Lenoir	59,436,323	17
Lincoln	22,500,000	5
Mecklenburg	8,341,290	2
Montgomery	20,000,000	5
Moore	12,929,743	5
Nash	69,741,783	22
New Hanover	10,873,720	3
Orange	45,861,014	13
Pearson	53,263,855	13
Pitt	31,304,000	10
Randolph	13,950,000	5
Richmond	35,231,123	12
Robeson	167,891,078	44
Rockingham	56,333,434	15
Rowan	4,927,097	1
Rutherford	4,715,880	2
Sampson	26,000,000	7
Scotland	60,311,599	19
Surry	17,952,841	5
Union	17,128,174	5
Vance	25,469,944	8
Wake	56,942,299	13
Warren	39,628,174	10
Wayne	122,684,986	39
Wilson	55,441,986	16
Grand Total	**2,044,509,794**	**573**

Source: Duke CGGC, based on NC-RETS

D. Grid-Connected PV Installations (MW_{dc}) by U.S. State, 2008-2013

State	2008	2009	2010	2011	2012	2013
Alabama	-	0.2	0.4	0.5	1.1	1.9
Alaska	-	-	-	-	-	0.2
Arizona	25.3	46.2	109.8	397.6	1,106.4	1,563.1
Arkansas	-	0.2	1.0	1.1	1.5	1.8
California	528.3	768.0	1,021.7	1,563.6	2,559.3	5,183.4
Colorado	35.7	59.1	121.1	196.7	299.6	360.4
Connecticut	8.8	19.7	24.6	31.1	39.6	77.1
Delaware	1.8	3.2	5.6	26.5	46.1	62.8
District of Columbia	0.7	1.0	4.5	11.6	13.9	16.5
Florida	3.0	38.7	73.5	95.0	116.9	137.3
Georgia	-	0.2	1.8	6.9	21.4	109.9
Hawaii	13.5	26.2	44.7	85.2	199.5	358.2
Idaho	-	0.2	0.4	0.4	1.0	1.8
Illinois	2.8	4.5	15.5	16.2	42.9	43.4
Indiana	-	0.3	0.5	3.5	4.4	49.4
Iowa	-	-	-	0.1	1.2	4.6
Kansas	-	-	-	0.2	0.5	1.1
Kentucky	-	-	0.2	3.3	4.8	7.9
Louisiana	-	0.2	0.2	13.4	18.2	46.6
Maine	0.3	0.3	0.3	1.1	2.8	5.3
Maryland	3.1	5.6	10.9	37.1	116.8	175.4
Massachusetts	7.5	17.7	38.2	74.6	207.3	445.0
Michigan	0.4	0.7	2.6	8.8	19.9	22.2
Minnesota	1.0	1.9	3.6	4.8	11.3	15.1
Mississippi	-	0.1	0.3	0.6	0.7	1.0
Missouri	-	0.2	0.7	2.0	18.5	48.9
Montana	0.7	0.7	0.7	0.7	2.2	3.0
Nebraska	-	-	0.2	0.3	0.4	0.6
Nevada	34.2	36.4	104.7	124.1	349.7	424.0
New Hampshire	0.1	0.7	2.0	3.1	5.4	9.6
New Jersey	70.2	127.5	259.9	565.9	955.7	1,184.6
New Mexico	1.0	2.4	43.3	165.5	203.4	256.6
New York	21.9	33.9	55.5	123.8	179.4	240.5
North Carolina	4.7	12.5	40.0	85.5	207.9	469.0
North Dakota	-	-	-	-	0.1	0.2
Ohio	1.4	2.0	20.7	31.6	79.9	98.4

State	2008	2009	2010	2011	2012	2013
Oklahoma	-	-	-	0.2	0.3	0.7
Oregon	7.7	14.0	23.9	35.8	56.4	62.8
Pennsylvania	3.9	7.3	54.8	133.1	164.3	180.2
Rhode Island	0.6	0.6	0.6	1.2	1.9	7.6
South Carolina	-	0.1	0.2	4.1	4.6	8.0
South Dakota	-	-	-	-	-	-
Tennessee	0.4	0.9	4.7	22.0	45.0	64.8
Texas	4.4	8.6	34.5	85.6	140.3	215.9
Utah	0.2	0.6	2.1	4.4	10.0	16.0
Vermont	1.1	1.7	2.9	11.7	28.0	41.5
Virginia	0.2	0.8	2.8	4.5	10.5	12.6
Washington	3.7	5.2	8.0	12.3	19.5	27.4
West Virginia	-	-	-	0.6	1.7	2.2
Wisconsin	3.1	5.3	8.7	12.9	21.1	22.5
Wyoming	-	0.1	0.2	0.2	0.6	1.0
Total	**791.7**	**1,255.7**	**2,152.5**	**4,011.0**	**7,343.9**	**12,090.0**

Note: Cumulative installed capacity reported in MW_{dc}. AC is 20% less than DC.

Source: IREC, "U.S. Solar Market Trends," Appendix C, 2008-2013

Endnotes

1 For purposes of this report, we define utility-scale solar as photovoltaic solar energy projects exceeding 1MW(ac). The (ac) reflects that solar capacity is reported either in alternating current (AC) or direct current (DC) terms because solar panels generate DC energy, which must then be converted to AC power for use by the electrical grid. DC is 20% greater than AC.

2 Sources for rankings are Interstate Renewable Energy Council (IREC), *U.S. Solar Market Trends 2013,* and the U.S. Energy Information Agency (EIA), as cited in Table 1.

3 Sources for the summary statistics are: solar jobs and number of companies, 2014 NCSEA N.C. Clean Energy Census; number of existing facilities and capacity, solar facilities greater than 0.9MW, reported to the N.C. Utilities Commission NC-RETS system as of February 6, 2015. Direct investment, annual cost/MW of installed capacity for years 2008-2014 imputed from NCUC Dockets or, in cases where cost was reported, the actual cost. Facilities under development (number and total MW), facilities reported in "Renewable Energy Facility Registrations Accepted by the NC Utilities Commission," as of December 31, 2014 minus existing operating facilities in the NC-RETS system as of February 6, 2015.

4 Ren 21, *Global Status Report*, 2014, 49; UNEP (Frankfurt School-UNEP Centre/BNEF, 2014; *Global Trends in Renewable Energy Investment 2014* (henceforth cited as UNEP, 2014)) estimates worldwide investment in all solar technologies as $12.1 billion in 2004 and $113.7 billion in 2013. Ren21 figures represent global investment in PV only. Both UNEP and Ren21 note the reduction of investment in 2013 from 2012 levels at about 20%.

5 Ren21, 2014, 47.

6 Solar Energy Industries Association (SEIA),U.S. *Solar Market Insight: 2013 Year in Review (*Washington, DC: 2014). Executive summary: https://www.seia.org/research-resources/solar-market-insight-report-2013-year-review

7 IREC, *U.S. Solar Market Trends 2013*, 2014, Appendix C (p. 29). Reported DC is converted to AC.

8 NC-RETS as of February 6, 2015 reports facilities operating and receiving renewable energy tax credits in North Carolina. NC-RETS is the basis for all our capacity information for North Carolina. We recognize that not all solar facilities are listed in the NC-RETS because not all facilities are interested in tradable credits; however, RETS is the best available source of information for operating capacity in North Carolina. SEIA (http://www.seia.org/research-resources/major-solar-projects-list) and EIA (Form 860) provide other lists of solar facilities. However, we chose to report data from NC-RETS as the basis of our estimate because (1) we wanted to rely on official statistics, and (2) we found the EIA data reported in Form 860 to lag that of the NC-RETS. The NC-RETS is available at http://www.ncrets.org/public-reports/). Readers interested in the list of all renewable energy projects (including solar) registered with the NCUC, regardless of operational status, should visit http://www.ncuc.commerce.state.nc.us/reps/reps.htm (look for the *Renewable Energy Facility Registrations Accepted by the NC Utilities Commission* file).

9 Ren21, *Global Status Report,* 2014.

10 Ren21, *Global Status Report,* 2014.

11 Colorado's Xcel Energy decided in October 2013 that big solar (and wind) projects were the most economic choice based on price alone, regardless of state renewable portfolio standards (Dave Levitan, "For Utility Scale Solar, Key Questions About the Future," *Yale Environment*, 360, 21 November, 2013).

12 Both Ethan Howland ("Large Utility-Scale Solar Development Slows to a Crawl," *Utility Dive*, 14 Jan. 2014) and Levitan, 2013 note that utility procurement already has slowed in many states due to bumping up to state REPS targets.

13 Denis Lenardic, "Large-scale Photovoltaic Power Plants Ranking 1-50," updated 14 January 2015, http://www.pvresources.com/PVPowerPlants/Top50.aspx

14 The implication of this trend is not to be underestimated. Distributed "small scale" (below 1MW) solar projects are coming under increased resistance by utilities, as the utilities are concerned with customer base reduction and lost revenue resulting from small-scale solar projects (Ren21; UNEP). Both Ren21 (p. 48) and UNEP (ch. 6) discuss the trend occurring in Europe, the United States, and Australia. They note that in several U.S. states, increased debate is occurring about the future of existing net metering laws. However, it is also true that – despite a 25% global investment reduction in 2013 of small-scale solar (UNEP, p. 56) – the United States saw an 11% growth (to $7.9 billion) of investment in small-scale solar in 2013 (UNEP), due (at least partly) to falling prices, the federal investment tax credit (in place until at least 2016) and innovative financing options that enable installation with little or no upfront costs to the consumer by third-party funders like Sunrun, SolarCity and SunPower (Ren21, p. 47; UNEP, p. 57.) With the exception of Japan (76% year-over-year growth (UNEP), where homebuilders promote solar homes as a product differentiation strategy (Ren21), the United States was unique in its growth of small-scale solar. In the United States, California is a noted leader in this size project. In North Carolina, barriers to small-scale solar are the inability to use third-party power purchase agreements and lack of access to consumer loans for financing the projects.

15 http://www.thesolarfoundation.org/research/national-solar-jobs-census.

16 Employment & revenue: 2014 NCSEA N.C. Clean Energy Census.

17 SEIA, "U.S. Solar Market Insight," Q3 2014.

18 Source of statement: Ren21, *Global Status Report*, 2014. As a reference point the cost/W was $76.67 in 1977, $10.00 in 1987, $6.10 in 1997, and $4.00 in 2007 (Bloomberg, *New Energy Finance,* http://www.abb-conversations.com/2013/12/7-impressive-solar-energy-facts-charts/).

19 Ren21, *Global Status Report,* 2014.

20 Value of shipments (modules); EIA, 2012; "Annual PV Cell/Module Shipments Report," Table 2. By peak kW, the

breakout is 61% silicon and 38% thin film, per EIA, “Annual PV Cell/Module Shipments Report,” 2012, Table 7.

21 EIA, “Annual PV Cell/Module Shipments Report,” 2012, Table 7.

22 Solar inverters convert the DC output of a photovoltaic solar panel into AC that can be fed into a commercial electrical grid or used by a local, off-grid electrical network (en.wikipedia.org/wiki/Solar_inverter).

23 James Montgomery, “Price Pressures Squeeze Solar Inverter Shipment Outlook,” *Renewable Energy World,* 16 Oct. 2013.

24 SEIA, *U.S. Solar Market Insight,* 2013.

25 EIA, “Annual PV Cell/Module Shipments Report,” 2012, Table 8.

26 EIA, “Annual PV Cell/Module Shipments Report,” 2012, Table 9.

27 SEIA, *U.S. Solar Market Insight,* 2014.

28 SEIA, *U.S. Solar Market Insight,* Q3 2014.

29 Concentrated photovoltaic (CPV) technology uses optics such as lenses or curved mirrors to concentrate a large amount of sunlight onto a small area of solar PV cells to generate electricity. China’s CPV continues to consolidate and is expected to be the most used solar technology by 2016. Market consolidation in CPVs is a trend in this technology. U.S.-based Solar Junction and Amonix have partnered to improve CPV efficiencies. New cell and conversion records for CPV continue to occur. Concentrated photovoltaic (CPV), historically a niche market, has seen production consolidations in Europe, the United States and China. In Europe, CPV has moved from Germany to France, with Soitec (France) partnering with Alstom to produce CPV in France. Soitec also has moved production facilities out of Europe to California. See en.wikipedia.org/wiki/Concentrated_photovoltaic; REN21; and Frank Haugawitz, “CPV Developments: China’s CPV Industry Too Is Facing Consolidation, May 2014 (http://www.frankhaugwitz.info/downloads.html).

30 A new technology promising efficient and inexpensive solar cells is based on perovskite materials, a rare earth mineral efficient at converting light into electrical energy. It can be manufactured using the same thin-film manufacturing techniques used for silicon solar cells. The promise of perovskite materials is an efficient and inexpensive solar cell. However, significant challenges remain to bring this solar technology to the commercial market, including the stability of the compounds outdoors and the toxicity of lead used in the perovskite solar cells. See http://www.cam.ac.uk/research/news/leds-made-from-wonder-material-perovskite#sthash.l6OxD3SQ.dpuf; http://en.wikipedia.org/wiki/Perovskite_%28structure%29#Material_properties; and http://www.nature.com/nmat/journal/v13/n9/full/nmat4065.html for additional information on perovskite cells.

31 Morgan Lee, “Kyocera to Develop Solar Projects in the U.S.,” UTSanDiego.com, 10 Sep 2013; “Hanqwa Q Cells Expands Commercial Rooftop Solar Services,” *PV News,* Dec. 2013.

32 SEIA, *U.S. Solar Market Insight,* 2013.

33 “Mosaic Awarded $1 Million, Plans International Expansion,” *PV News,* Feb. 2014, p. 5.

34 https://joinmosaic.com/solar/north-carolina, last accessed Oct 8, 2014.

35 As a reference point, low = 2kWh/m2/day; medium = 4kWh/m2/day; high = 7.5kWh/m2/day; http://www.symtechsolar.com/pv-resources/return-of-investment/.

36 SEIA, *U.S. Solar Market Insight,* 2013.

37 IREC reports in MWdc. We converted the reported DC into AC for the figures provided in the table. See Appendix C for annual reporting by state in DC.

38 IREC 2014; EIA, Electricity Generation and Consumption (EIA-906/920/923), Net Generation by state by sector (Table 1.6). EIA data are available electronically at http://www.eia.gov/electricity/data/browser/

39 Total investment calculated based on the annual cost per MW of installed solar reported in NCUC documents. See note 3 for additional details.

40 RTI, “Economic Impact of Clean Energy Development in North Carolina,” 2014 update (April 2014) places the investment of solar facilities in the state at $1.5 billion.

41 See note 3 for sources.

42 http://www.rmi.org/Content/Files/BOSReport.pdf.

43 http://wiki-solar.org/index.html.

44 See Duke Energy Renewables, “Solar Power Project Fact Sheet”, available at http://www.duke-energy.com/pdfs/Solar-Power-Projects-Fact-Sheet.pdf

45 The discussion for this section is based on NREL, *Federal and State Structures to Support Financing Utility-Scale Solar Projects and the Business Models Designed to Utilize Them* (NREL/TP-6A20-48685), 2012.

46 See section 2.1.1 of NREL 2012 for additional information on this point.

47 Bloomberg *New Energy Finance*, 2010

48 NREL, 2012.

49 NREL, 2012.

50 NREL, 2012, pp. 30-32.

51 Coughlin J. and Cory, K. (March 2009) *Solar Photovoltaic Financing* NREL/TP-6A244853. Golden, CO: National Renewable Energy Laboratory.

52 Readers interested in global trends in renewable energy financing should consult UNEP, 2014 (*Global Trends in Renewable Energy Investment 2014).*

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55 The companies are Entropy Solar (York Capital Management) and FLS Energy (New Energy Capital). See http://www.newenergycapital.com/nec_investments.html

56 UNEP, 2014.

57 UNEP, 2014.

58 For typical returns on investment in North Carolina, see the 2014 testimony of Jonathan Gross in the Avoided Cost docket E-100 Sub 140 of the NCUC, p. 202.

59 Carus, 2013.

60 Carus, 2013.

61 UNEP, 2014; Carus, 2013.

62 UNEP, 2014.

63 SEIA, *U.S. Solar Market Insight,* 2013.

64 "SunEdison yield co nets extra cash from IPO," PV-Tech, July 24, 2014 http://www.pv-tech.org/news/sunedison_yield_co_nets_extra_cash_from_ipo.

65 "Mosaic Awarded $1 Million, Plans International Expansion," *PV News,* Feb. 2014, p. 5.

66 UNEP, 2014.

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