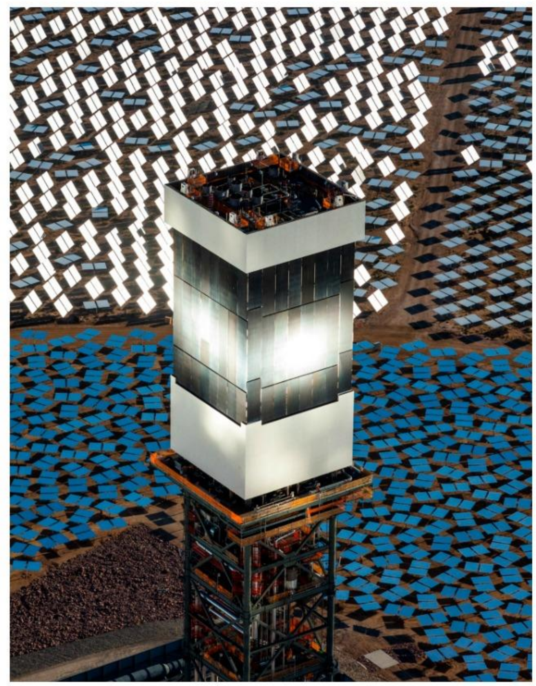
SEIA Solar Energy Industries Association®

Cutting Carbon Emissions Under §111(d):

The case for expanding solar energy in America



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Solar Energy Industries Association

Celebrating its 40th anniversary in 2014, the Solar Energy Industries Association® is the national trade association of the U.S. solar energy industry. Through advocacy and education, SEIA® is building a strong solar industry to power America. As the voice of the industry, SEIA works with its 1,000 member companies to champion the use of clean, affordable solar in America by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

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Executive Summary

Solar energy is a solution technology that can provide a cost-effective, economically beneficial and integral part of a state's effort to regulate carbon emissions from the electric sector. Solar energy's rapidly falling prices and rapidly growing generating capacity, as well as the volatility of fossil fuel prices, give solar energy the potential to transform compliance with both new carbon emission requirements and other existing requirements under the Clean Air Act.

In June 2013, President Obama announced that the Environmental Protection Agency (EPA) will propose carbon pollution standards for existing power plants under §111(d) of the Clean Air Act. While the carbon pollution standards will apply to all major fossil fuel power plants, the EPA is expected to allow for flexibility in how states choose to reduce emissions from their power plant fleets.

Historically, air pollution emission reduction from the electric sector has been achieved primarily through pollution control equipment at power plants. Today, the EPA and states recognize that the reduction of carbon emissions from the electric sector requires a new approach that treats the production and delivery of electric power as a broad system, in which power plant modifications, demand side reductions and renewable energy all contribute to emission reductions.

This report explains the advantages to states of incorporating solar energy in their energy portfolios in light of the forthcoming §111(d) regulations for existing power plants. Because solar energy emits zero carbon emissions while generating reliable energy, increasing solar energy deployment will help states meet the carbon standards under §111(d). Increasing solar will also help achieve compliance with other clean air objectives, including the Cross State Air Pollution Rule (CSAPR) and the National Ambient Air Quality Standards (NAAQS). Moreover, the steady decline in solar energy costs makes it a cost-effective solution to grid operations, state energy independence and water supply challenges, while simultaneously lowering long-term electricity supply costs and providing economic benefits. Regulators will find that the variety of solar energy systems, which enable solar technologies to fit in large and small areas and in a wide range of locations, and the speed of solar deployment makes solar energy among the most flexible tools for meeting emissions goals while serving key energy needs.

Solar contributes to a balanced portfolio of energy resources, and can help achieve an optimal long-term strategy for each state's economy and environment. By including solar energy as part of their §111(d) compliance plan, states can cost-effectively meet their Clean Air Act requirements while reaping a wide range of additional benefits.

Introduction:
Regulating Carbon Emissions Under Section 111(d) of the Clean Air Act

WHY REGULATE CARBON EMISSIONS UNDER SECTION 111(D) OF THE CLEAN AIR ACT?

The May 2014 release of the third National Climate Assessment report highlighted the evidence that climate change is happening now in the U.S. and that impacts from the increasing global temperature are already being felt across the nation.[1] In June 2013, President Obama announced a Climate Action Plan that would address the U.S. contribution of greenhouse gas (GHG) emissions to the atmosphere. One piece of this plan calls for the reduction in carbon emissions from existing power plants.

THE EPA'S AUTHORITY TO REGULATE CARBON EMISSIONS UNDER SECTION 111(D) OF THE CLEAN AIR ACT

The EPA has the authority to regulate air pollution, including GHG emissions, under the Clean Air Act. The EPA regulates criteria air pollutants, such as smog pollutants, through the National Ambient Air Quality Standards (NAAQS) established under §109 of the Clean Air Act.[2] For pollutants not covered by NAAQS, the EPA may control emissions by setting new source performance standards for industrial source categories through §111. To employ this authority to control GHG emissions, the EPA is required to take a number of procedural steps. The EPA first determined that carbon emissions from large coal and gas facilities cause harm to health and the environment.[3] Next, the EPA proposed carbon emission standards for new power plants under §111(b) (large coal and gas facilities are hereafter referred to as "covered sources").[4] Once new sources in this category are controlled, the EPA must establish emission guidelines by which states regulate these emissions from existing power plants under §111(d).

These standards must be based on the "best system of emission reductions."[5] Each state will then create a §111(d) compliance plan to meet the EPA's standard of performance for covered sources.[6] While owners of covered sources are responsible to meet the carbon pollution standards, states will be charged with developing plans to

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[1] The full report, "Climate Change Impacts in the U.S." is available here: http://nca2014.globalchange.gov.

[2] NAAQS standards have been set for sulfur dioxide, particulate matter, ozone, lead, carbon monoxide, and nitrogen dioxide. (http://www.epa.gov/air/criteria.html)

[3] In 2009, the EPA conducted an endangerment finding and declared greenhouse gas (GHG) emissions to endanger public health and welfare as a significant contributor to climate change, prompting the need for regulation under the Clean Air Act. This finding is available at: http://www.epa.gov/climatechange/endangerment/ This finding was then confirmed by the United States Supreme Court in Massachusetts v. EPA, 549 U.S. 497 (2007). More info is available at http://www.supremecourt.gov/opinions/06pdf/05-1120.pdf.

[4] 42 U.S.C. §7411(b)(1)(B). EPA Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 FR 22392 (April 13, 2012) and 79 FR 1430 (January 8, 2014)

[5] 42 U.S.C. §7411(a)(1)

[6] 42 U.S.C. §7411(d)(1); While §111(d) points to §110 state implementation plans (SIPs) when addressing state compliance, the language is not specific as to a certain method of compliance. This suggests that the EPA may allow for more flexibility in §111(d) compliance plans than SIPs, and that federal enforceability may be different under §111(d) than under §110. Therefore, this report references state plans under §111(d) as state "compliance plans" rather than state implementation plans or SIPs.

ensure compliance through a state §111(d) compliance plan. Once a state has created its compliance plan, the EPA has the authority to either approve the plan or impose its own plan if a state fails to establish controls necessary to meet the EPA's standard of performance.[7]

WHAT IS SOLAR ENERGY?

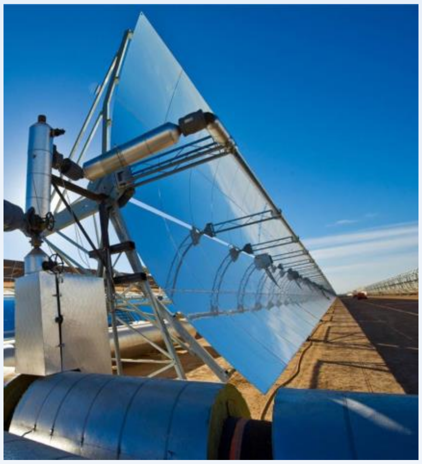
There are multiple forms of solar energy technologies, each with its own unique performance capabilities and benefits. Including an array of solar technologies within an energy portfolio allows the states to take advantage of the complementary characteristics each solar technology offers. The U.S. has some of the best solar resources available in the world and solar energy can be deployed in all 50 states.[8] Some of the benefits offered by the various solar technologies include zero carbon emissions, grid support services, price certainty, avoided health costs, significantly reduced water use, and increased investment in state economies. Below is a description of the primary types of solar energy technologies.

1. Utility-Scale/Wholesale: Utility-scale solar refers to larger-sized solar power plants designed to sell solar-generated electricity to wholesale utility buyers. There are a number of characteristics unique to large-scale installations that make them attractive to utilities, including advanced operational characteristics, large quantities of solar power at a low cost, and long-term fixed pricing that provides a hedge against fuel volatility.
    a. Photovoltaic (PV): Photovoltaic devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to send electricity to the grid. Today's utility-scale photovoltaic (PV) systems can include advanced features that enable these plants to provide many of the characteristics of conventional power plants and to

Solar Technology

Utility Scale Photovoltaic

Concentrating Solar Power



[7] 42 U.S.C. §7411(d)(2)
[8] For detailed maps showing solar insolation in each state, see NREL's solar maps here: http://www.nrel.gov/gis/solar.html

actively contribute toward the stability and reliability of a regional grid as part of a balanced energy portfolio. As of the end of 2013, the total U.S. cumulative installed capacity of utility-scale PV was 5.8 GW_{dc}.[9]

b. Concentrating Solar Power (CSP): CSP uses mirrors to concentrate the sun's thermal energy to drive a conventional steam turbine to produce electricity. CSP can be integrated with storage, which allows thermal energy to be stored for later use. In this way, CSP with thermal energy storage provides flexibility to grid operators, offering power that can be dispatched as needed, day or night. CSP plants utilize conventional steam turbine power blocks, like those of conventional plants, but use the sun as the source of heat instead of fossil fuels. This allows CSP plants to provide the grid support services (called "ancillary services") historically offered by conventional plants, such as frequency response, spinning and non-spinning reserves and ramping. As of the end of Q1 2014, there are 1435 MW_{ac} of CSP facilities operating in the U.S. An additional 1,100 MW_{ac} of CSP capacity is expected to come online in the U.S. by the end of 2016.

2. Distributed Resources
   a. Photovoltaic (PV): The basic technology used by distributed PV to produce electricity is the same as described in the PV section above. However, distributed generation, or DG, refers to PV solar electricity produced at or near the point where it is used. DG solar can be located on rooftops or ground-mounted and is typically connected to the local utility distribution grid. States, cities and towns are implementing policies to encourage DG in order to offset peak electricity demand, reduce grid congestion and improve air quality. As of the end of 2013, the total U.S. cumulative installed capacity of DG PV was 6.3

Solar Technology

PV / Distributed Generation

Solar Heating and Cooling

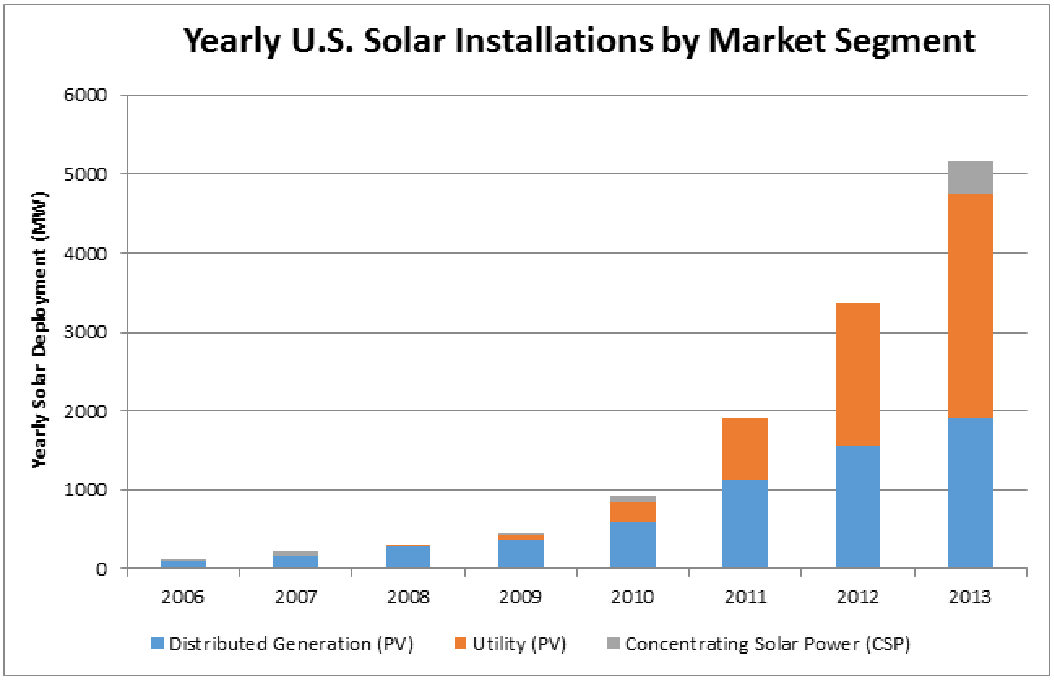
[9] U.S. Solar Market Insight Report, 2013 Year in Review. Report available here: http://www.seia.org/research-resources/us-solar-market-insight

GW_{dc}.[10] With emerging technologies, DG can be coupled with storage, frequency response and voltage support equipment to help meet peak evening demand and provide ancillary services.

b. Solar Heating and Cooling (SHC): SHC technologies collect thermal energy from the sun and use this heat to provide hot water, space heating and cooling and pool heating for residential, commercial and industrial applications. These technologies displace the need to use electricity or natural gas.[11] The SHC industry currently has a goal of 300 GW_{th} of SHC by 2050. Deployment at this scale would provide enormous benefits for homeowners, businesses and taxpayers, and generate nearly 8 percent of the total heating and cooling needs in the U.S., resulting in nearly $100 billion annually in positive economic impacts.[12]

More information about the size and scope of the U.S. solar industry is available on SEIA's website: www.seia.org. This site provides a detailed profile of the solar energy in each state, showing the average solar insolation, the current cumulative installed capacity in that state, the number of solar companies creating jobs and other information.

The chart below shows the growth of the solar industry since 2006.



[10] U.S. Solar Market Insight Report, 2013 Year in Review. Report available here: http://www.seia.org/research-resources/us-solar-market-insight

[11] For more information: http://www.seia.org/policy/solar-technology/solar-heating-cooling

[12] Solar Heating and Cooling: Energy for a Secure Future. Full report available here: www.seia.org/shca

WHAT IS THE CONNECTION BETWEEN SOLAR ENERGY AND SECTION 111(D)?

Solar energy can provide a basis for compliance under §111(d) regulations in two very important ways. First, solar energy, other renewable energy sources and energy efficiency should be considered as part of a "best system of emissions reduction" by the EPA when establishing the stringency of the standard of performance for regulated sources. Second, the EPA is likely to allow states to use solar and other renewables as compliance options.

1. Solar Energy Should be Used to Determine the Standard of Performance

Section 111(d) requires the EPA to establish a standard of performance for covered sources based on a best system of emissions reduction.[13] When determining the "best system," the EPA must take into account the cost of achieving the proposed emissions reduction, as well as any non-air quality health, environmental and energy requirements.[14]

States have proven that solar energy and other renewable resources are effective ways of producing energy without carbon emissions as part of a balanced energy portfolio. Therefore, the "best system" of emission reduction should acknowledge solar energy and shift the traditional way of thinking about an energy system from emission controls at the covered sources to including energy sources that reduce the overall emissions of the energy system by displacing fossil fuel combustion — whether at the covered sources or at an off-site location. This enables the EPA to set a meaningful standard for covered sources that encourages the deployment of renewable energy to reduce total carbon emissions.

2. Solar Energy is a Competitive Compliance Option as Part of a Balanced Energy Portfolio

The EPA has publicly stated on numerous occasions that it will allow states significant flexibility to comply with §111(d). This will allow each state to choose the best and most cost-effective way to meet the emission standard for its particular circumstances. Solar energy is well-suited as a §111(d) compliance option for states because it emits no carbon emissions, and because many solar technologies can be deployed quickly and easily virtually anywhere, making it one of the most flexible sources available to meet both energy needs and emission reduction requirements. In addition, solar avoids a number of costs and issues associated with fossil generators, including fuel, water use, air and water pollution and combustion waste disposal, and can reduce costs for transmission and distribution equipment. Furthermore, the EPA will likely allow states to use current and new solar policies to count towards carbon emissions reductions.

Thus, as a solution technology, solar energy should be viewed as an integral part of a state's overall effort to regulate its carbon emissions from fossil fuel power plants.

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[13] 42 U.S.C. §7411(d)(1)(A); 42 U.S.C. §7411(a)(1)
[14] Id.

Why States Should Take Advantage of Solar Under Section 111(d)

Solar energy should be part of a state's compliance portfolio because it reduces carbon emissions in a cost-effective manner while providing other non-air quality, health, environmental and economic benefits. By taking a holistic perspective, air and energy regulators will find that adopting solar energy as part of a §111(d) plan makes compliance and economic sense.

1. REDUCE CARBON EMISSIONS WITH SOLAR ENERGY

Solar energy is not a hypothetical way to reduce carbon emissions; solar power generation significantly reduces carbon emissions today. Solar energy systems in the U.S. are expected to generate more than 20,000 gigawatt hours (GWh) in 2014.[15] With one GWh of solar generation eliminating 690 metric tons of CO_2 emissions, solar generation can be expected to avoid 13.8 million metric tons of CO_2 emissions in 2014.[16]

Emission reductions resulting from solar deployment are certain to grow. In 2013 alone, the solar industry grew 53 percent over 2012, installing 5.2 GW of solar generating capacity. On average, a new solar project was installed in the U.S. every 4 minutes in 2013.[17] Solar energy accounted for 29 percent of new electric generation capacity installed in 2013.[18] An approximate 6.8 GW of new solar capacity is projected to come online in 2014.[19]

The EPA's Avoided Emissions and Generation Tool (AVERT) can be used to calculate the carbon emissions reductions from solar energy using historic dispatch data.[20] The chart on the next page shows the current CO_2, NO_x and SO_2 avoided in each AVERT region at current solar energy deployment levels.[21]

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[15] SEIA analysis based on data from SEIA/GTM Research U.S. Solar Market Insight: 2013 Year in Review

[16] For more information, see http://www.epa.gov/cleanenergy/energy-resources/refs.html

[17] U.S. Solar Market Insight 2013 Year in Review Report. Available at: www.seia.org/smi.

[18] U.S. Solar Market Insight 2013 Year in Review Report. Available at: www.seia.org/smi.

[19] SEIA analysis based on data from SEIA/GTM Research U.S. Solar Market Insight: 2013 Year in Review and EIA Electric Power Monthly, December 2013, Table ES3.

[20] The AVERT tool statistically determines the marginal electric generating units (EGUs) on an hourly basis. The AVERT tool is free to use with a simple user interface designed to meet the needs of state air quality planners and other interested stakeholders, and can easily be used to evaluate county-level emissions displaced at EGUs by EE/RE policies and programs, and to analyze the emission benefits of different renewable energy programs in multiple states within an AVERT region. The tool can also be used to quantify the nitrogen oxides (NO_x), sulfur dioxide (SO_2), and carbon dioxide (CO_2) emissions benefits of state and multi-state renewable policies and programs. Read more here: http://epa.gov/statelocalclimate/resources/avert/index.html

[21] Solar deployment data taken from SEIA/GTM Research U.S. Solar Market Insight: 2013 Year in Review and SEIA solar industry 2012 data. Report available here: http://www.seia.org/research-resources/us-solar-market-insight. Hawaii and Alaska have been excluded; the total MW of cumulative capacity in each state have been split equally between the utility PV and rooftop PV specifications in the model; states in multiple AVERT regions have had their cumulative capacity divided equally among the multiple AVERT regions the state is present in, with the exception of Texas. All Texas cumulative solar capacity was run in the Texas AVERT region.

AVERT REGION	STATES WITHIN AVERT REGION	CUMULATIVE CAPACITY (MW)	CO_2 EMISSIONS REDUCED (TONS)	SO_2 EMISSIONS REDUCED (POUNDS)	NO_X EMISSIONS REDUCED (POUNDS)
California	CA, UT	5171.70	4,433,300	705,700	6,340,000
Great Lakes/ Mid-Atlantic	DE, IL, IN, KY, MD, MI, NJ, OH, PA, VA, WI, WV	1241.90	1,325,700	6,069,800	2,406,700
Lower Midwest	AR, KS, LA, MO, NM, OK, TX	141.48	180,800	418,300	394,800
Northeast	CT, MA, ME, NH, NJ, NY, RI, VT	1408.35	1,113,600	1,972,900	1,574,000
Northwest	ID, MT, NV, OR, UT, WA, WY	312.70	329,800	389,800	785,200
Rocky Mountains	CO, SD, WY	331.50	464,000	647,900	899,300
Southeast	AL, AR, FL, GA, KY, LA, MO, MS, NC, OK, SC, TN, TX, VA, WV	927.03	959,800	2,975,400	1,486,000
Southwest	AZ, CA, NM, NV, TX	1850.40	2,070,300	977,800	2,987,300
Texas	TX, OK	201.20	203,600	408,800	236,800
Upper Midwest	IA, IL, MI, MN, MO, MT, ND, NE, SD, WI	72.43	94,500	286,000	170,800

An increase in the amount of electricity produced from solar decreases the amount of electricity produced by fossil fuel power plants. While solar may not replace polluting sources on a 1:1 basis, due to the complexity of the grid and electric system, generally when solar is placed on the grid it displaces electricity production from a source that emits carbon pollution, often at a high rate, such as a simple-cycle natural gas generator.

Numerous studies have shown the extent to which renewable energy can effectively reduce emissions. The Western Wind and Solar Integration Study, performed by the National Renewable Energy Laboratory (NREL), evaluated the impacts of operating the Western Interconnect with high penetrations of wind and solar. The study found that CO_2 emissions could be reduced by 29 percent-34 percent, or the equivalent of 260-300 billion pounds per year when the Western Interconnect obtains 33 percent of electricity from wind and solar.[22]

In February 2014, PJM, the nation's largest grid operator (with territory covering 13 states and Washington, DC), released a study analyzing a high penetration of renewable generation on the PJM grid. The study considered scenarios of up to 30 percent wind and solar and found no significant operating issues. In addition, the study

[22] Western Wind and Solar Integration Study, available at: http://www.nrel.gov/electricity/transmission/western_wind.html

found that CO_2 emissions could be reduced by 28 percent in the "High Solar Best Onshore" scenario compared to the business as usual (BAU) scenario in the target year 2026.[23]

In February of 2012, the U.S. Department of Energy (DOE) released the SunShot Vision Study, a detailed report that examines the potential for and barriers to solar PV and CSP in the U.S., while striving for reduced solar costs. The report states:

> *Solar energy reduces GHG emissions compared with most other sources of energy. Compared with the reference scenario, the SunShot scenario is estimated to reduce electric-sector operational carbon dioxide (CO_2) emissions by 181 million metric tons (MMT) per year by 2030 (an 8 percent reduction), and the estimated reduction by 2050 is 760 MMT per year for the SunShot scenario (a 28 percent reduction)…. Significant reductions in U.S. GHG emissions are projected under the SunShot scenario. Combined with other efforts worldwide, these reductions have the potential to contribute significantly to the deceleration of global climate change.*[24]

Furthermore, life-cycle GHG emissions from PV and CSP, as assessed in the SunShot Vision study, are orders of magnitude lower than lifecycle GHG emissions from natural gas and coal power plants.[25]

2. STATES CAN MEET OTHER CLEAN AIR ACT REQUIREMENTS WITH SOLAR ENERGY

Solar energy can also help states reduce emissions of acid gases and air toxics and can help attain ambient air quality standards for ozone. While solar is generally not a source-based emissions control technology for these pollutants, the addition of solar energy into the electric sector can displace the need for fossil fuel combustion that generates these regulated pollutants.[26] The EPA is not only promulgating new regulations under §111(d), but it is also regularly revising and enforcing existing air regulations. For example, solar energy can offer significant co-benefits when the new ozone and PM standards are implemented, and solar can help meet state emission budgets for pollutants controlled under the Cross State Air Pollution Rule (CSAPR) and the National Ambient Air Quality Standards (NAAQs).

The Western Wind and Solar Integration Study found that if the Western Interconnect obtained 33 percent of electricity from wind and solar, SO_x emissions could be reduced by 14 percent-24 percent, or the equivalent of 80-140 million pounds per year, and that NO_x emissions could be reduced by 16 percent-22 percent, or the

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[23] PJM Renewable Integration Study, available at: http://www.pjm.com/~/media/committees-groups/committees/mic/20140303/20140303-pris-executive-summary.ashx

[24] For additional figures, see http://www1.eere.energy.gov/solar/pdfs/47927_chapter7.pdf. Chapter 3 of the SunShot Vision study describes the SunShot and reference scenarios, including descriptions of the modeled electricity capacity and generation mixes and discussion of peak and baseload power resources.

[25] Id.

[26] It should be noted that some types of solar technologies can reduce emissions from coal- or natural gas- fired power plants at the plant itself. For example, solar can be added to heat to power blocks that would otherwise be provided by combustion, or by drying coal, pre-heating boiler feed water, and other source-based measures.

equivalent of 170-230 million pounds per year.[27] Likewise, the PJM Renewable Integration Study found that in the "High Solar Best Onshore" scenario, the SO_x emissions could be reduced by roughly 150 million pounds per year, and the NO_x emissions could be reduced by more than 100 million pounds per year compared to the BAU scenario in the target year 2026.[28] Mercury emissions and PM2.5 emissions are also avoided by renewable energy generation.

The chart below shows the regulatory calendar and compliance timeframe for air regulations under the Clean Air Act in addition to §111(d).[29] The chart, while not exhaustive, shows how the co-benefits provided by solar can contribute to compliance for a range of Clean Air Act requirements.

EPA Rules	2013	2014	2015	2016	2017	2018
Existing Power Plants §111(d)		Rule proposed 6/1	Final rule 6/1	Compliance due 6/30		
New Power Plants §111(b)	Revised 9/20					
MATS			Existing Sources: 4/16	4th year extension	5th year extension	Case-by-case extension
CSAPR						
Carbon Monoxide monitoring			1/1: population > 2.5 million+		1/1: population < 2.5 million	
NAAQS for Lead	June: state plans due					

Proposed Rule
Final Rule
Draft Compliance Rules Due
Fully Enforced

[27] Western Wind and Solar Integration Study, available at: http://www.nrel.gov/electricity/transmission/western_wind.html
[28] PJM Renewable Integration Study, available at: http://www.pjm.com/~/media/committees-groups/committees/mic/20140303/20140303-pris-executive-summary.ashx
[29] Other near-term rules that solar can assist a state in achieving compliance with are the ozone rule in January 2015 and the PM 2.5 rule expected in April 2014.

3. IMPROVE GRID RELIABILITY AND ENERGY INFRASTRUCTURE AS PART OF A BALANCED ENERGY PORTFOLIO WITH SOLAR ENERGY

As part of a balanced energy portfolio, solar can improve grid reliability and provide significant relief to existing energy infrastructure by reducing transmission losses and relieving congestion on the grid. Further, §111(d) creates an opportunity for utilities and policymakers to enhance their efforts at addressing the changing grid operations presented by increased renewable penetration.

a. Reliability and Transmission Benefits of Solar

Solar energy can be configured and operated to provide various reliability services and transmission benefits that will be essential to electric power system operations in conjunction with the state implementation of §111(d) regulations.

With supportive policies and standards in place, solar PV can include advanced features that enable it to operate more like conventional power plants and actively contribute to the stability and reliability of a regional grid as part of a balanced energy portfolio.[30] Some of these features may include voltage regulation, active power controls, ramp-rate power controls, fault ride-through, and frequency response controls. These advanced features can enable solar PV to provide a state or region with additional system flexibility by responding to utility and independent system operator instructions.

Concentrating solar power plants employ conventional synchronous turbine generators and inherently possess valuable system reliability attributes, such as, but not limited to, active and reactive power support, dynamic voltage support and regulation, voltage control and some degree of inertia response. With the integration of thermal energy storage, CSP facilities can be fully dispatched by utilities and system operators, meaning that the plants are capable of ramping power output up and down to meet changing energy demand, without material efficiency losses. In addition, CSP with storage plants are a significant source of essential grid flexibility services, such as ramping, regulation and spinning reserves, which are critical to a reliable system. These services are typically provided by fossil-fired generators operating at sub-optimal heat rates, which may increase their emissions.

On an aggregated basis, utility-scale and distributed solar resources provide significant reliability and transmission benefits to a state or regional grid, even if solar output varies at a few individual locations due to localized cloud coverage. When the sum of the solar installations in a geographic area is assessed, the variability is reduced and can be managed by the grid operator. In a recent study regarding the integration of wind and solar in PJM, General Electric International, Inc. (GE) found that PJM's large geographic footprint significantly reduced the magnitude of variability-related challenges as compared to smaller balancing areas.[31] GE noted that an individual

[30] See "Grid-Friendly" Utility Scale PV Plants, First Solar at 3 and 13 (August 13, 2013).
[31] See PJM Renewable Integration Study, General Electric International, Inc. at 12 (February 28, 2014) (GE Study).

solar plant's variability is significantly reduced when solar plants are aggregated and located in a geographically diverse manner throughout PJM.[32]

Further, targeted deployment of solar in congested areas provides relief to transmission systems, defers costly transmission upgrades, and helps maintain grid reliability. For example, unlike central station power plants, solar installed on-site does not experience transmission and distribution system losses, which can be as high as 7 percent on a utility distribution system and up to 20 percent at the time of system peak.[33] Similarly, utilities may site small utility-scale power plants in specific locations to ease congestion on a particular transmission line.

Finally, solar technologies that require transmission investment often do not require pipelines, coal transport or the associated production and processing infrastructure needed by coal and gas industries. This has the potential to save immense costs as the energy infrastructure in the U.S. ages and requires repairs.

b. Adapting to Changing Grid Operations

As renewable energy becomes a larger component of the electricity sector, the generation profile of the electric resources available throughout the day is changing. For example, solar and wind resources peak at specific times depending on geography and other factors. While utilities previously sought to procure a least-cost mix of energy to meet a predictable load curve, the addition of renewable energy has spurred utilities and regulators to think differently about matching supply and demand.

Utilities and policymakers are already addressing the changes to grid operations presented by increased renewable penetration. For example, in areas of an electric grid where the peak energy use is in the late afternoon or evening, solar systems can be configured to coincide with peak demand later in the day or be coupled with storage technologies to match their output to local power demand patterns. This can be done economically, if supported through appropriate policies, pricing options, and program offerings.[34] For a discussion of strategies to address the changes to grid operations presented by renewables, we recommend *Teaching the Duck to Fly*, a paper recently published by the Regulatory Assistance Project.[35]

4. BALANCE COMPLIANCE COSTS WITH SOLAR ENERGY

Section 111(d) has the potential to create a new regulatory paradigm that would allow regulators to take advantage of valuable renewable energy sources as compliance options. This is distinctly different from previous air regulations, which typically required regulators to construct compliance plans around technologies that reduced

[32] See Id. at 12 and 15.

[33] For more information, see the paper, "Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements" available at: www.raponline.org/document/download/id/4537

[34] See "Teaching the Duck to Fly: Integrating Renewable Energy," available here: http://www.raponline.org/featured-work/teach-the-duck-to-fly-integrating-renewable-energy

[35] Id.

emissions output and increased operation costs for covered sources. Under §111(d), regulators will still be required to reduce carbon emissions but will likely have the flexibility to balance the cost of regulations with the opportunities presented by a diverse energy portfolio. Solar energy should be one piece of that portfolio.

Solar is already cost-competitive with new fossil generation in certain circumstances. Solar is rapidly becoming competitive with existing fossil generation as well.[36] For example, in 2013 Xcel Energy received approval from the Colorado Public Service Commission to procure 170 MW of solar strictly on a cost competitiveness basis.[37] In addition, solar recently outbid natural gas in a competitive evaluation for utility resource planning in Minnesota.[38]

The cost to install PV is decreasing rapidly as well. Nationally, the average price of a residential PV installation declined 9 percent in Q4 2013 over Q4 2012.[39] Between 2006 and 2013, the capacity-weighted average installed price of PV fell from $7.90/W_{dc}$ to $2.59/W_{dc}$.[40] In fact, the economics of utility-scale PV have never looked more attractive to utilities, which are now signing power purchase agreements in the $50-$60/MWh range over 20 to 25 years, offering price certainty to both utilities and ratepayers. For example, Recurrent recently executed a power purchase agreement with Austin Energy in Texas for less than $0.05/kWh.[41] These costs will continue to decline as economies of scale are achieved. The chart on the next page shows the recent decline in costs of PV installations.

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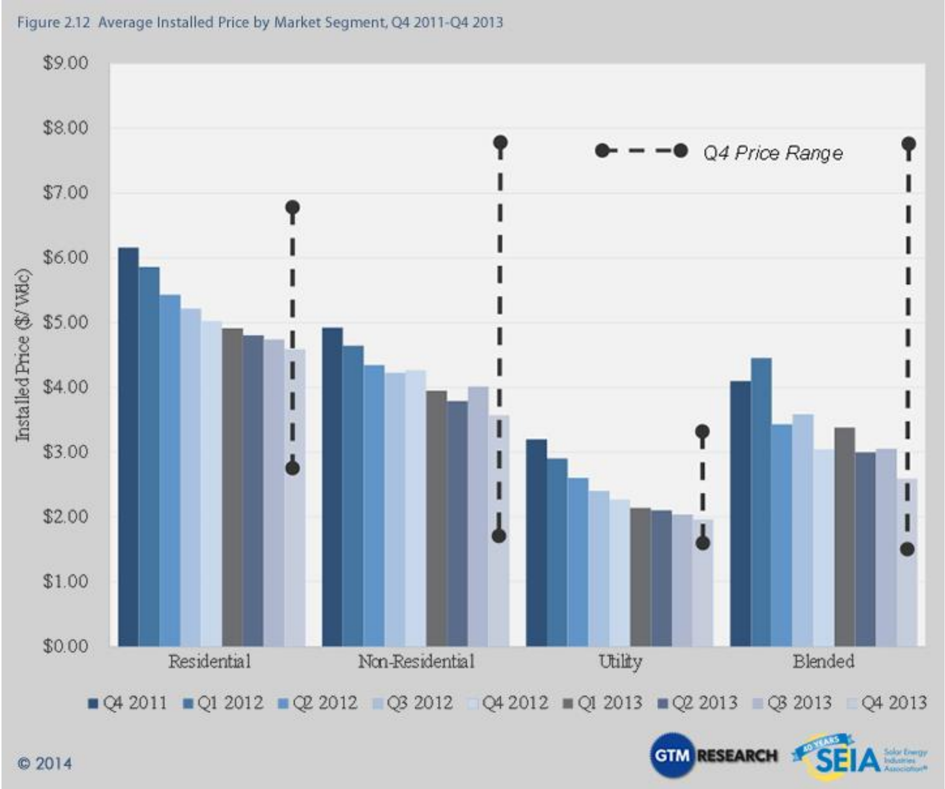
[36] More info available at: http://www.greentechmedia.com/articles/read/Cheapest-Solar-Ever-Austin-Energy-Buys-PV-From-SunEdison-at-5-Cents-Per-Ki
[37] More info available at: http://www.xcelenergy.com/About_Us/Energy_News/News_Archive/Xcel_Energy_proposes_adding_economic_solar,_wind_to_meet_future_customer_energy_demands
[38] More info available at: http://www.renewableenergyworld.com/rea/news/article/2014/01/minn-judge-solar-beats-natural-gas-for-utility-procurement
[39] U.S. Solar Market Insight 2013 Year in Review Report. Available at: www.seia.org/smi.
[40] Id.
[41] http://www.greentechmedia.com/articles/read/Austin-Energy-Switches-From-SunEdison-to-Recurrent-For-5-Cent-Solar.



With solar, the costs over time can be made transparent and fixed over the length of the contract. Importantly, solar energy is not subject to the same price volatility as fossil fuel generation.[42] Once a solar system is constructed, the fuel is free. This allows contracted solar energy to offer the stability of a long-term, fixed energy price for the term of the contract (generally, anywhere from 10 to 30 years). Even when conventional generation offers long-term contracts, the price usually varies, as they are pegged to fluctuating fuel prices.[43]

Some stakeholders have expressed concerns that solar and wind energy can increase costs and energy system emissions due to an increased need to cycle conventional power plants in response to variable renewable output.[44] However, such claims have been proven to be overstated, and could largely be avoided through a balanced portfolio of complementary solar, wind and other clean energy resources. The Western Wind and Solar Integration study found that not only is a high renewable energy penetration achievable, but also that any increases in costs or emissions associated with increased cycling of fossil fuel power plants are nominal compared to the overall cost

[42] In fact, Renewables Portfolio Standards, such as the California program, were initially adopted primarily for fuel diversity and hedging purposes, in response to the 2001 energy crisis that resulted in significant part from reliance on natural gas supplies.

[43] While fuel-price hedging contracts exist, the terms of the contracts can be limited and tend to be very expensive.

[44] Western Wind and Solar Integration Study, available at: http://www.nrel.gov/electricity/transmission/western_wind.html (Citing cycling concerns at pg. vii)

and emissions savings associated with reduced generation from fossil fuel power plants.[45] The PJM Renewable Integration Study reached a similar conclusion: any increased costs associated with increased cycling of conventional generators are dwarfed by the savings in fuel costs.[46]

5. SOLAR CREATES LOCAL JOBS AND ECONOMIC INVESTMENT

The deployment of solar energy provides jobs in every single U.S. state. According to The Solar Foundation's *Solar Job Census 2013*, there are nearly 143,000 solar workers in the U.S., a 20 percent increase over employment totals in 2012.[47] These workers are employed at 6,100 businesses operating at more than 7,800 locations across the country.[48] The increasing value of solar installations has injected life into the U.S. economy as well. In 2013, solar electric installations were valued at $13.7 billion, compared to $11.5 billion in 2012.[49]

The renewable industry has significant potential to be an engine for even greater employment and economic benefits. According to the U.S. DOE's SunShot Vision Study, continued cost reductions and steady increases in installed solar capacity will lead the solar industry to employ over 340,000 workers by 2030.[50]

6. REDUCE WATER CONSUMPTION WITH SOLAR GENERATION

In addition to reducing GHG emissions, solar energy utilizes very minimal amounts of water in comparison to traditional fossil fuel resources. In fact, PV operates using no water. In all steam-cycle thermal power plants, whether fossil, nuclear or solar, heat is used to boil water into steam, which runs a steam turbine to generate electricity. The exhaust steam from the generator must be cooled prior to being heated again and turned back into steam.[51] This cooling can be done with water (wet cooling) or air (dry cooling), or a combination of both (hybrid cooling). PV and concentrating PV solar plants are not thermal cycle plants and therefore do not require water for cooling. When employing dry-cooling technology, parabolic trough and power tower solar plants consume less than 50 gallons/MWh, a small fraction of the water used by a natural gas fired (200 gallons/MWh), coal-fired (500 gallons/MWh) or nuclear power plant (800 gallons/MWh).[52]

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[45] Western Wind and Solar Integration Study, available at: http://www.nrel.gov/electricity/transmission/western_wind.html

[46] PJM Renewable Integration Study, available at: http://www.pjm.com/~/media/committees-groups/committees/mic/20140303/20140303-pris-executive-summary.ashx

[47] National Solar Job Census 2013, available at: http://thesolarfoundation.org/research/national-solar-jobs-census-2013

[48] SEIA National Solar Database.

[49] National Solar Job Census 2013, available at: http://thesolarfoundation.org/research/national-solar-jobs-census-2013

[50] The Solar Foundation, Financing the Next Generation of Solar Workers: An Exploration of Workforce Training Program Sustainability in the Context of Reduced Public Funding. November 2012. Available at: http://thesolarfoundation.org/sites/thesolarfoundation.org/files/SWIC%20Final.pdf U.S. Department of Energy, *SunShot Vision Study*. February 2012. Available at http://www1.eere.energy.gov/solar/sunshot/vision_study.html

[51] For more information: http://www.seia.org/policy/power-plant-development/utility-scale-solar-power/water-use-management

[52] Water consumption figures are approximate. For more information about water use and solar, see http://www.nrel.gov/docs/fy11osti/49468.pdf

7. AVOID HEALTH COSTS ASSOCIATED WITH FOSSIL FUEL POWER PLANTS

Solar energy does not produce as many costly externalities as fossil sources.[53] Emissions from coal power, for example, can cause bronchitis, asthma, heart disease, water pollution, land degradation and more — all in addition to climate change.[54] One study concluded that, when monetized, the "social cost" of coal-fired power could be as high as 60 percent of residential electricity prices.[55] Similarly, the EPA determined that particulate exposure from coal-fired power costs Americans between $110 billion and $270 billion each year.[56] When energy sources are adjusted to account for these externalities, solar energy becomes even more cost-competitive.[57]

8. ACHIEVE TIMELY COMPLIANCE WITH SOLAR ENERGY

The speed of solar deployment, along with the modularity of solar, makes it a great choice for meeting incremental generation needs and can assist states in quickly achieving compliance with EPA regulations under §111(d). The development and construction timeline for a large, centralized conventional fossil fuel power plant is typically a multi-year process (and longer for nuclear energy). By comparison, the time from conception to operation for renewable energy projects can be much faster. While very large solar and wind plants are still subject to some of the same siting and permitting-related requirements as large fossil plants, medium and small solar facilities can be built quickly, especially with the right policies in place. In places with streamlined permitting and interconnection procedures, it is possible for a three-person crew to install up to three residential PV systems in a day. For larger commercial flat-roof PV systems, a six-person crew can install 100 kW of PV in a day.

9. PAST RATIONALE FOR EXCLUDING SOLAR FROM AIR PLANS DOES NOT APPLY TO SECTION 111(D)

Historically, solar energy has not been included in past air plans for a number of reasons. Past air regulations have focused primarily on emission control measures that reduce emissions at the covered source or through changes in fuel composition. However, the more flexible approach under §111(d) could take advantage of emission-displacing technologies not located at the covered source in addition to those "within the fence line."

Additionally, solar technology may not have been thought of as a compliance option for the Clean Air Act in the past because of concerns about whether it was commercially proven and economically viable. Over the last several years, the solar industry has advanced significantly in deployment, scale and cost reduction. Recognizing this fact, in 2012 the EPA published a roadmap for incorporating renewable energy and energy efficiency policies

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[53] Externalities are defined as the costs unaccounted for by the price of a product.

[54] Towards the Full Cost of Coal: A review of the recent literature assessing the negative health care externalities associated with coal-fired electricity production (Caroline Burkhard Golin 2012).

[55] Epstein, P. R., Buonocore, J. J., Eckerle, K., Hendryx, M., Stout Iii, B. M., Heinberg, R., ... Glustrom, L. (2011). Full cost accounting for the life cycle of coal. *Annals of the New York Academy of Sciences, 1219*(1), 73-98. Per Towards the Full Cost of Coal: A review of the recent literature assessing the negative health care externalities associated with coal-fired electricity production (Caroline Burkhard Golin 2012).

[56] Regulatory Impact Analysis for the Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone in 27 States; Correction of SIP Approvals for 22 States (U.S. EPA Office of Air and Radiation 2011), per Solar Electricity: Economic Development and Impact (presentation by Lee J. Peterson, Esq. 2012).

[57] Solar Electricity: Economic Development and Impact (presentation by Lee J. Peterson, Esq. 2012).

and programs into state and tribal state implementation plans for compliance with pollutants under §110 of the Clean Air Act.[58]

How States Can Include Solar Under Section 111(d)

The EPA is considering two approaches to reducing carbon emissions for existing power plants under §111(d). One is a "rate-based" approach in which emission reductions are expressed as tons of CO_2 emissions per megawatt hour of electricity (tons CO_2/MWh) generated by an existing power plant.[59] The second is a "mass-based" approach in which emission reductions are expressed as total tons of carbon emissions allowed (tons CO_2) across the electric-generating system.[60] With either approach, states will be required to reduce carbon emissions while maintaining electric system reliability and keeping costs down.

There are likely two compliance pathways states can follow that will lead to reduced carbon emissions from the electric sector under §111(d). The first pathway involves emission control measures at the covered source (also referred to as "inside the fence" measures). The second pathway involves measures that can be adopted that are not located at the covered source (also referred to as "outside the fence" measures). Solar energy can be successfully used in both pathways.

INSIDE THE FENCE SOLAR MEASURES

"Inside the fence" measures are applied at the covered source. Traditional inside the fence measures include heat-rate improvements, fuel switching and averaging of emissions within a single source, among others. Inside the fence solar measures would likely involve hybridization of a station's fuel source with solar-generated heat from a CSP system. At new or existing oil, natural gas and coal fired power plants, CSP technologies can be deployed to produce high pressure, high temperature air or steam, which can be integrated into these facilities' thermal cycles, such as direct injection into a high pressure turbine or for pre-heating of feed-water.[61]

A "hybrid" CSP-fossil plant uses solar energy to produce heat that displaces[62] some or all of the heat that would otherwise be derived from fossil fuel combustion to drive the turbines. This allows the power plant to reduce its emissions by avoiding fossil fuel combustion with CSP technology. For example, Florida Power & Light's (FPL)

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[58] See the full EPA Roadmap "Incorporating Energy Efficiency and Renewable Energy into State and Tribal Implementation Plans" here: http://epa.gov/airquality/eere/

[59] If the EPA sets a "rate-based" standard on power plants, it is likely the EPA will allow this standard to be translated into an overall emissions budget to provide states with compliance flexibility.

[60] Under the mass-based approach, each state would calculate a CO_2 emissions reduction budget expressed as a CO_2 reduction amount by a specific year relative to a defined baseline year. For example, the mass-based target could be set as a 17percent reduction in carbon emissions by 2020 compared to 2014 carbon emission levels.

[61] "Solar-Augment Potential of U.S. Fossil-Fired Power Plants" February 2011. *See* http://www.nrel.gov/docs/fy11osti/50597.pdf

[62] Alternatively, solar steam can be used augment existing steam production ("solar boost mode") to increase a power plant's output without a commensurate increase in fossil fuel consumption or emission.

Martin Next Generation Solar Energy Center is an example of a hybrid CSP-fossil plant operating at commercial scale in Florida. The Martin plant currently displaces approximately 90,000 tons of carbon emissions each year.[63]

OUTSIDE THE FENCE SOLAR MEASURES

"Outside the fence" measures reduce carbon emissions using technology not located at the covered source. Air regulators will need to involve energy officials within the state in order to develop a §111(d) compliance plan, allowing states to maintain reliability and reasonable electricity rates while reducing carbon emissions. Regulators can consider the mix of resources available, along with electricity imports and exports, to create a balanced energy portfolio that satisfies their compliance requirements under §111(d). A balanced energy portfolio could contain a solar target that air regulators can then monitor as part of an overall compliance plan.

There are a wide variety of proven methods to achieve a certain targeted deployment of solar energy. For example, a state may use incentive programs, tax programs, or renewable portfolio standards to reduce carbon emissions statewide through increased renewable deployment. The chart below[64] shows the top 10 states for solar deployment in the U.S. and the range of solar policies and programs that contributed to a successful solar market in each state. Each policy and program varies in many ways; regulators can customize their approach to the particular circumstances and needs of their state.

The solar industry is committed to working with states to implement effective solar policies on a state-by-state basis. SEIA intends to provide further assistance to states on how to include solar in a §111(d) compliance plan after the proposed rule is released in the summer of 2014.

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[63] In 2010, 75 MW of CSP was added to an existing 3,705 MW combined cycle natural gas plant at this facility. *See* http://www.fpl.com/environment/solar/pdf/Martin.pdf; http://www.cleanenergyactionproject.com/CleanEnergyActionProject/CS.FPL_Martin_Next_Generation_Solar_Energy_Center___Hybrid_Renewable_Energy_Systems_Case_Studies.html

[64] The chart is representative of the portfolio of programs adopted by states, but does not include all solar or renewable energy programs.

	STATE	CUMULATIVE PV CAPACITY (MWDC), AS OF 12/31/13	CUMULATIVE CSP CAPACITY (MWAC), AS OF 12/31/13	PORTFOLIO OF SOLAR POLICIES AND PROGRAMS DRIVING GROWTH[65]
1	California	5171.7	488.0	CSI, NEM, RPS, Utility Procurement, PACE
2	Arizona	1539.4	283.0	RPS, NEM
3	New Jersey	1211.3		RPS/SRECs, NEM, PSE&G Loan Program
4	North Carolina	556.6		Tax Credit, Utility Standard Offer Contracts
5	Nevada	385.6	64.0	RPS, NEM, NV Energy Rebate Program
6	Massachusetts	440.4		RPS/SRECs, NEM, Solarize Mass, RGGI member
7	Hawaii	335.6	7.0	Tax Credit, NEM
8	Colorado	331.2		NEM, Utility Procurement (Xcel Solar*Rewards), RPS
9	New York	247.1		NY-Sun initiative: NYSERDA Rebate and LIPA FIT, NEM, RGGI member
10	New Mexico	236.4		RPS, NEM

[65] The following are abbreviated: CSI= CA Solar Incentive Program; NEM = net metering; PACE = property assessed clean energy program; RPS = Renewable Portfolio Standard; FIT = Feed-in Tariff; RGGI = Regional Greenhouse Gas Initiative

Quantifying Carbon Emissions from Solar

A state that uses solar as part of its compliance portfolio will need to quantify the emissions reductions from solar. This requires tracking solar energy generation and calculating the emissions reductions associated with the electric sector.

a. Tracking Solar Energy Generation

States, electric utilities and regional grid operators have demonstrated successful methods for measuring solar energy production. It is now standard practice for solar systems, including residential, commercial and large-scale applications, to have metering equipment in place to measure generation in order to ensure compliance with requirements of power purchase contracts and incentive programs. The meters can show the output of a solar system on an hourly or more frequent basis. This solar production data could be made available to air regulators.

b. Quantifying Emissions Reductions

There are several methods for calculating the carbon emission reductions from renewable energy. The four main methods include modeling of energy systems, historic generation and emissions data, capacity factor based emission rates and system average emission rates. The EPA has already provided guidance to states on how to incorporate renewable energy and energy efficiency measures to reduce criteria pollutants under §110 of the Clean Air Act. The guidance also instructs states on how to measure, verify and credit renewable energy for carbon emission reduction.[66]

Conclusion

Solar energy, as part of a balanced energy portfolio, can provide significant reductions in carbon and other air emissions, and should be considered as an essential element in any §111(d) compliance strategy. The solar industry encourages each state to create a §111(d) compliance plan that includes solar as a keystone compliance measure. Ultimately, carbon reductions will likely be achieved by a mix of inside and outside the fence measures. Solar can significantly reduce carbon emissions under either approach, while providing jobs, economic benefits, and large quantities of clean, cost-competitive power.

As the United States begins to address carbon emission from the electric sector, solar can contribute to an optimal long-term strategy for each state's economy and environment. The solar energy industry is committed to working with states to take advantage of the opportunities presented by solar and §111(d).

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[66] More information on the Roadmap can be found here: http://epa.gov/airquality/eere/. Appendix I on "Methods for Quantifying Energy Efficiency and Renewable Energy Emission Reductions" is available here: http://epa.gov/airquality/eere/pdfs/appendixI.pdf

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