Gliding Toward a Clean Energy Future: Arizona Responds to the EPA's Clean Power Plan







November 2015

SONORAN INSTITUTE

www.sonoraninstitute.org

About Sonoran Institute

Founded in 1990, the Sonoran Institute's mission is to connect people and communities with the natural resources that nourish and sustain them. We work at the nexus of commerce, community, and conservation to help people in the North American West build the communities they want to live in while preserving the values which brought them here. We envision a West where civil dialogue and collaboration are hallmarks of decision-making, where people and wildlife live in harmony, and where clean water, air, and energy are assured.

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About the Sun Corridor Program

The Sun Corridor Legacy Program is one of the four keystone initiatives of the Sonoran Institute. The "Sun Corridor" refers to Arizona's megapolitan region stretching from Nogales in the south to Prescott in the north, with Phoenix and Tucson at its core. The megapolitan is growing at a tremendous rate, and that rapid growth comes with the challenge of conserving natural desert and open space while improving urban quality of life. The Sun Corridor Legacy Program's three focus areas are:

- **Envisioning** a healthy and prosperous Sun Corridor region;
- **Engaging** diversity in environmental issues and decision-making; and
- **Enhancing** the community by promoting strategic conservation initiatives.

The Sun Corridor's desirable climate, housing options, and relatively low cost of living are reasons why this region continues to attract new residents. Future quality of life, environmental quality, and economic prosperity will largely be determined by how well growth is managed. Going forward, regional solutions that comprehensively address conservation, development, transportation, water, and energy issues will be critical to a more sustainable future.

Arizonans must consider these regional issues when making decisions about how to develop communities, preserve cherished open spaces, ensure an adequate high-quality water supply, protect our quality of life, and enhance economic prosperity. New approaches to problem solving are needed to make this happen, and the Sonoran Institute finds them through work with federal, state, and local governments, and stakeholder groups to determine the best mix of land use and conservation for lands in the region. To find out more about the program visit www.sonoraninstitute.org.

Connect with the Sun Corridor Program on Twitter: @suncorridor

Prairie Fire Solar Project

About ASU Energy Policy Innovation Council

The Energy Policy Innovation Council informs and educates policymakers on current, complex issues in energy policy that impact Arizona and beyond. We are housed within the Center for Law, Science and Innovation at the Sandra Day O'Connor College of Law at Arizona State University in Tempe, Arizona.

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Acknowledgments

This study was made possible through the generous support of the William and Flora Hewlett Foundation and the Energy Foundation.

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The Sonoran Institute also thanks members of the study's advisory group for their guidance and suggestions. Their participation does not imply endorsement of the study's build-out scenario or final recommendations. Members of the advisory group are listed in Appendix A.

Fort Huachuca Solar Array

Valencia Solar Array

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Executive Summary

On August 3, 2015, the U.S. Environmental Protection Agency issued standards to limit carbon dioxide emissions from existing electricity generation facilities. Commonly referred to as the Clean Power Plan (CPP), this rule has the potential to significantly advance the energy sector's ongoing transition to a low-carbon future, providing the nation with greater access to clean, safe, and reliable sources of energy.

The CPP provides significant flexibility to states in reaching their individual carbon emissions reductions. Beyond simply reducing emissions at electricity generation facilities, the CPP encourages a combination of approaches that includes development of natural gas, renewable energy, nuclear energy, and energy efficiency in conjunction with actions that reduce overall energy demand as substitutions to on-site emissions reductions.

This study demonstrates that in Arizona, large- or utility-scale renewable energy can play a vital role in achieving the carbon emission reductions laid out in the CPP. It is, in part, a build-out scenario—exploring one alternative to build additional large-scale solar and wind generation facilities, based on very specific and realizable assumptions:

- Projects that have been fully permitted, but do not have a power purchase agreement (PPA), enter into contracts with Arizona utilities that seek to purchase their power.
- Other promising projects conclude their planning or permitting process in the next two years and secure PPAs with Arizona utilities.
- New projects come forward and are located in areas that have been identified by a broad range of stakeholders as potentially suitable for large-scale solar and wind development.

Our build-out scenario projects 4,312 MW in new energy generation capacity, half of which could be operational by 2022, the CPP's interim deadline, with the balance on line by the plan's final deadline of 2030.

While this build-out scenario includes detailed references to projects and locations, it is not intended to be prescriptive, but rather illustrative of the tremendous potential in Arizona for large-scale solar and wind energy resources. In addition, the second half of the study raises important issues regarding the actions and responses that state and federal decision-makers, utilities, solar and wind developers, and others may take in realizing this scenario as part of the Clean Power Plan implementation and the general promotion of Arizona's clean energy future. They include recommendations to:

Promote siting opportunities on U.S. Bureau of Land Management (BLM) lands for large-scale renewable projects that may assist the state in meeting its carbon-reduction goals under the Clean Power Plan rule.

Work collaboratively to further evaluate the viability of Solar Energy Zones (SEZs) and Renewable Energy Development Areas (REDAs) for renewable energy development.

Create an inter-agency task force to coordinate and expedite environmental reviews of proposed large-scale renewable energy generation projects in response to the Clean Power Plan rule.

Facilitate large-scale renewable energy development in response to the Clean Power Plan rule by extending development incentives accorded to the BLM's SEZs to REDAs.

Fully fund the first regional periodic review of West-wide Energy Corridors (Section 368), covering western Arizona, southern Nevada, and the California desert.

Advocate for the consideration of detailed renewable energy build-out scenarios in regional transmission planning.

Evaluate a renewable energy build-out scenario similar to this project as a component of the Arizona Corporation Commission's biennial energy assessment.

Evaluate detailed renewable energy build-out scenarios as part of utilities' integrated resource planning processes.

Assess policies or other actions that would compensate utilities and developers for providing ancillary services along with renewable energy generation.

Introduction

On August 3, 2015, the U.S. Environmental Protection Agency (EPA) issued standards to limit carbon dioxide (CO_2) emissions—a potent "greenhouse gas" contributing to climate change— from existing electricity generation facilities. Commonly referred to as the Clean Power Plan (CPP), this rule is projected to result in a 20 percent reduction in power plant emissions by 2030 based on what emissions were in 2012.[1] Consequently, the rule has the potential to significantly advance the energy sector's ongoing transition to a low-carbon future, providing the nation with greater access to clean, safe, and reliable sources of energy.

Arizona is well positioned to take advantage of the CPP. It boasts unparalleled solar resources, a diverse land portfolio for locating renewable energy (RE) projects, and a transmission system that can deliver those renewable resources to markets in and out of the state. Additionally, Arizona has been a leader in setting policies that advance RE; it was one of the first states to require regulated utilities to generate a certain percentage of their electricity from renewable resources.

The CPP provides significant flexibility to states in reaching their individual CO_2 emissions reductions. Beyond simply reducing emissions at electricity generation facilities, the plan encourages a combination of approaches that includes development of natural gas, RE, nuclear energy, and energy efficiency in conjunction with other actions that reduce overall energy demand as substitutions to on-site emissions reductions. This flexibility continues the progress that Arizona and other states have made in diversifying their energy portfolios. Additionally, states can work together to comply with the plan, creating a greater number of emission reduction options, which can likely be achieved at a lower cost and in a more efficient manner. If states refuse to submit a plan, the EPA will impose its own federal plan, which in all probability will involve some sort of "cap and trade" program.

This study demonstrates that large- or utility-scale RE can play a vital role in achieving the carbon emission reductions laid out in the CPP. It is, in part, a build-out scenario—exploring one alternative to build additional large-scale solar and wind generation facilities, based on very specific and realizable assumptions:

- Projects that have been fully permitted, but do not have a power purchase agreement (PPA), enter into contracts with Arizona utilities that seek to purchase their power.
- Other promising projects conclude their planning or permitting process in the next two years and secure PPAs with Arizona utilities.
- New projects come forward and are located in areas that have been identified by a broad range of stakeholders as potentially suitable for large-scale solar and wind development.

While this build-out scenario includes detailed references to projects and locations, it is not intended to be prescriptive, but rather illustrative of the tremendous potential in Arizona for large-scale solar and wind energy resources. In addition, the second half of the study raises important issues regarding the actions and responses that state and federal decision-makers, utilities, solar and wind developers, and others may take in realizing this scenario as part of the Clean Power Plan implementation and the general promotion of Arizona's clean energy future.

Agua Caliente Solar Array Photo Credit: First Solar

What is a Build-out Study?

Build-out studies are a planning tool used to forecast future growth and its associated impacts based on land available for development. When used in tandem with population projections, it can help determine how much development will occur in the future, where it will occur, and what steps local jurisdictions and state and federal agencies may take to accommodate future development.

In the context of the CPP, a build-out study could similarly forecast potential RE development based on available land adequate to accommodate large-scale solar and wind development. Such a broad assessment might be helpful in underscoring the availability of land and its capacity for RE development in Arizona. However, a slightly more refined approach may ultimately prove more useful—one that focuses on a set of solar and wind projects with near-term development potential and a subset of lands that may meet a range of suitability criteria for development within the CPP's interim (2022-2029) and final (2030) deadlines.

This project- and location-specific approach is particularly relevant to state and federal decision-makers, utilities, and developers because any large-scale RE build-out scenario must not only assess site-specific considerations but also the scenario's broader impact on the electricity transmission or "grid" system. This is especially true if the scenario in question considers significant increases in renewable energy generation within a defined geographic area. As with a conventional build-out study, this study concludes with a discussion of steps needed to realize this scenario.

What is the Clean Power Plan?

Issued by the EPA under Section 111(d) of the Clean Air Act and officially known as Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, the Clean Power Plan (CPP) limits carbon dioxide (CO2) emissions from existing electricity generation facilities (U.S. EPA).

The CPP includes mandatory carbon reduction targets for each state. The EPA calculated these targets after determining what constitutes the "best system of emission reduction," estimating the emissions from the affected power plants covered under this rule, and providing states with three approaches, or "blocks," to achieve their emissions reductions:

1. More efficient coal plant operations.

2. Greater reliance on (lower-carbon) natural gas plants

3. Increased use of renewable (no-carbon) resources, like solar, wind, geothermal, hydropower, and biomass.

While the EPA has identified these primary approaches, the agency acknowledges that other options are available to states, including energy efficiency and nuclear power.

The states' carbon reduction, or emission targets will be legally binding, but states have the flexibility to choose among these three approaches to meet their targets. It is worth noting that the EPA is quite bullish about states' ability to deploy additional RE in response to the plan—in large part because wind and solar prices have dropped in the past year—and believes that RE could provide more than 20 percent of the nation's electricity supply by 2030 (U.S. EPA 2015b).

In contrast to the draft rule, the EPA is providing states with more time to develop and implement their plans in response to the CPP. States now have two years to develop their plans (instead of one) and do not have to meet interim targets until 2022 (instead of 2020). The latter change prompted the EPA to offer a Clean Energy Incentives Program in order to still meet the U.S.'s international commitment to cut emissions 17 percent by 2020. This program provides states with emissions credits for solar and wind projects that begin construction once a state submits its final plan. These credits are provided for each MWh of clean power generated by these projects and can be awarded to electricity generation facilities in order to comply with the plan (U.S. EPA).

The EPA also provides states with flexibility in selecting between two types of emission targets. States can choose between a "rate-based" target, which is defined by the amount of carbon generated per unit of energy produced, or a "mass-based" target, which is the total amount of carbon emitted through energy production. There are pros and cons to each approach. If a state adopts a "rate-based" approach, they can technically increase some plant emissions to respond to specific energy demands as long as the overall carbon intensity of power plants goes down. If they adopt a "mass-based" approach, the EPA estimates states may find it cheaper to comply with the CPP, as well as easier to put in place a "cap and trade" program.

Under the plan, Arizona will need to cut its carbon emissions rate from 1,552 to 1,031 (lbs/Net MWh) or overall emissions from 40,465,035 to 30,170,750 (short tons) by 2030.[2] Mandatory reductions start in 2022 with additional benchmarks through 2030 (what the EPA calls the "glide path" to compliance). These targets are less stringent than originally proposed for Arizona, putting it in the middle range of the CPP's individual state emissions targets.

In developing Arizona's targets, the EPA assumes that the state would continue to work on reducing carbon emissions from their power plants while increasing their reliance on renewables. However, the EPA's assumptions do not impose any requirements on individual states or imply a preferred implementation strategy on their part. Their assumptions are primarily used to demonstrate that each state's goal is reasonable and achievable. Ultimately, states must develop their own implementation plans, with a mix of coal, gas, renewables, and other options tailored to meet their particular circumstances.

Arizona's Renewable Energy Bounty

Arizona's renewable resources make it well positioned to take advantage of the CPP. First, Arizona boasts outstanding solar resources. As figure 1 demonstrates, Arizona is among four states that have the highest rates of "solar insolation" (amount of sun hours per day).[3] The total sun hours and overall weather conditions make the state ideal for development of both photovoltaic and thermal solar energy.

Second, Arizona benefits from a diverse land portfolio for locating large-scale solar and wind projects. Figure 2 presents the results of a statewide assessment of federal, state trust, and private lands that were initially screened and found potentially suitable for solar and wind development (a total of more than 1.8 million acres of federal, state trust, and private lands).[4]

Third, the state's extensive transmission system could deliver renewable resources to markets in Arizona and neighboring states like California. In part, this is due to the Palo Verde Hub, which harbors one of the largest concentrations of electricity generation facilities in North America,[5] but also because Arizona's electricity consumption has outpaced the national average growth rate (Considine and McLaren 2008). To balance energy demand and supply, Arizona updates its plans for building new transmission every two years, and as part of this biennial planning process has identified transmission lines that could facilitate delivery of RE to markets (Arizona Corporation Commission).

Fourth, Arizona has been a leader in setting policies that advance RE. It was one of the first states to require regulated utilities to generate a certain percentage of their electricity from renewable resources.[6] The state's Renewable Energy Standard has proven to be successful in stimulating RE development in Arizona, which ranked fifth in the nation in installed solar capacity in 2014 (247 MW) and second in cumulative installed capacity (2,143 MW) (Solar Energy Industry Association).

Finally, while this study focuses on the role that large-scale solar and wind development can play in meeting Arizona's CPP targets, distributed solar (commonly referred to as "rooftop" solar) and community solar (where various homeowners or energy users pool resources to build or purchase solar collectively) are also important components. An effective and comprehensive clean energy response to the CPP relies on an "all of the above" approach to RE development, which Arizona may consider in its response to the CPP.

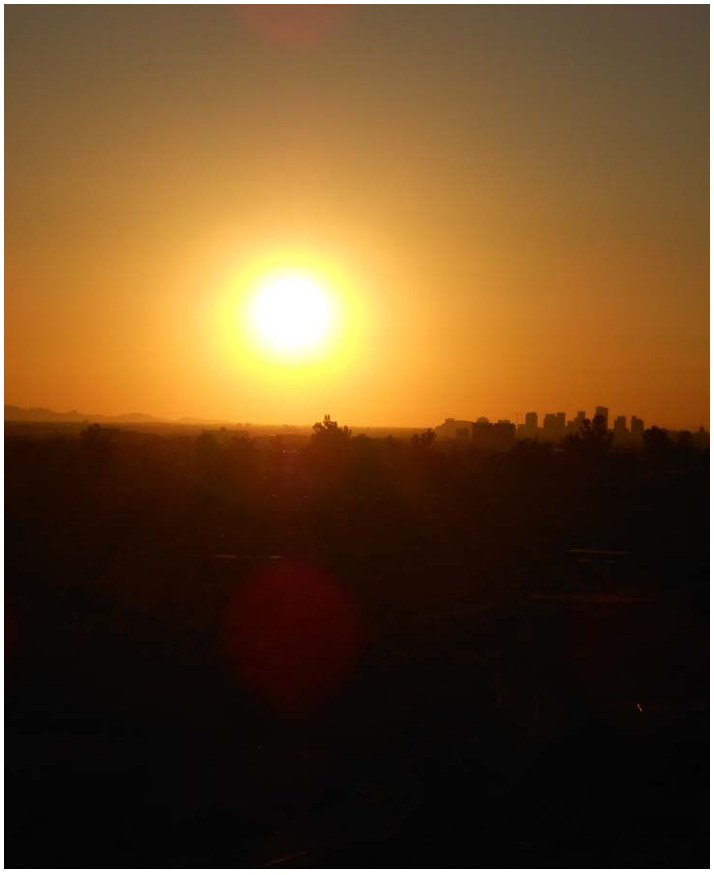
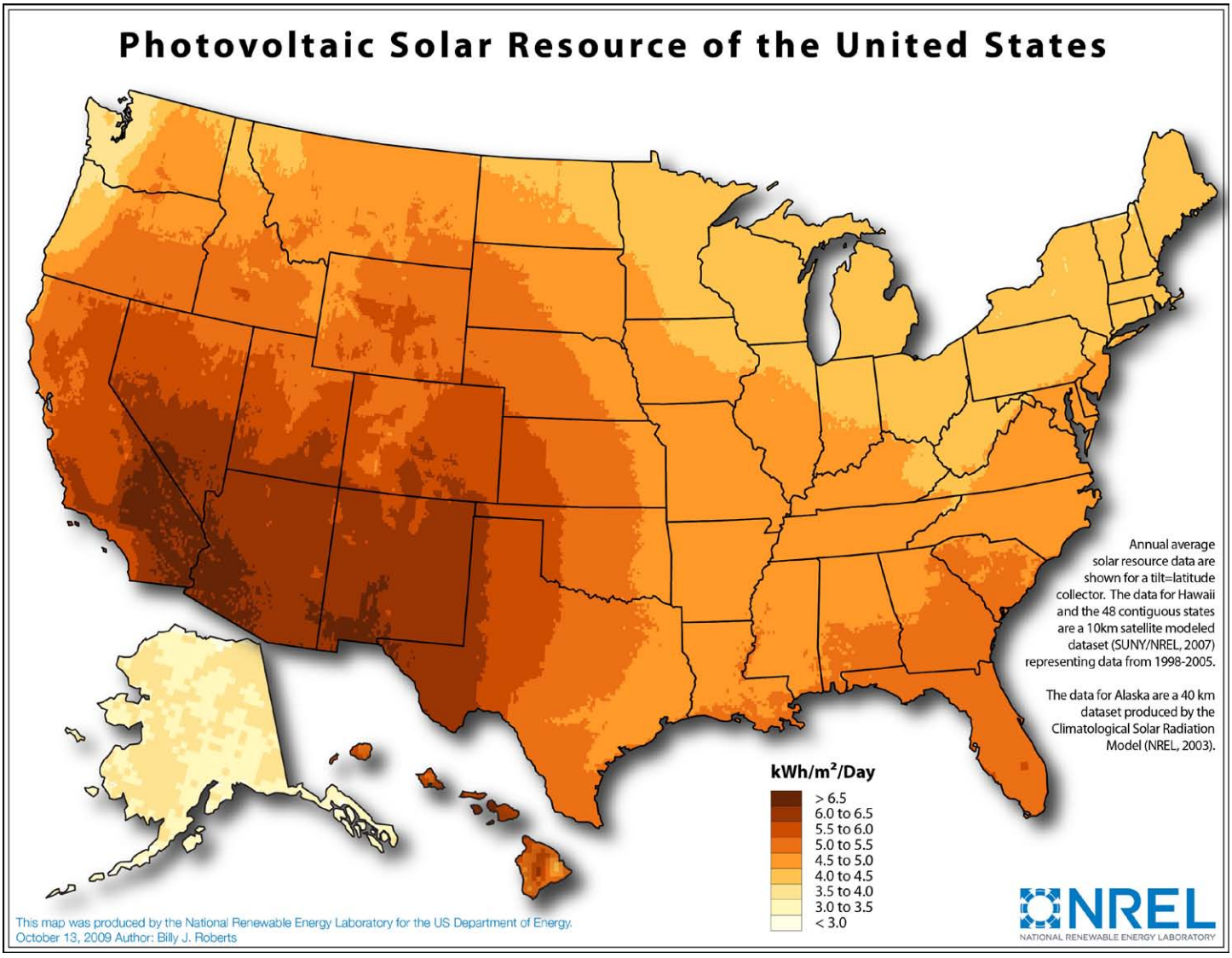
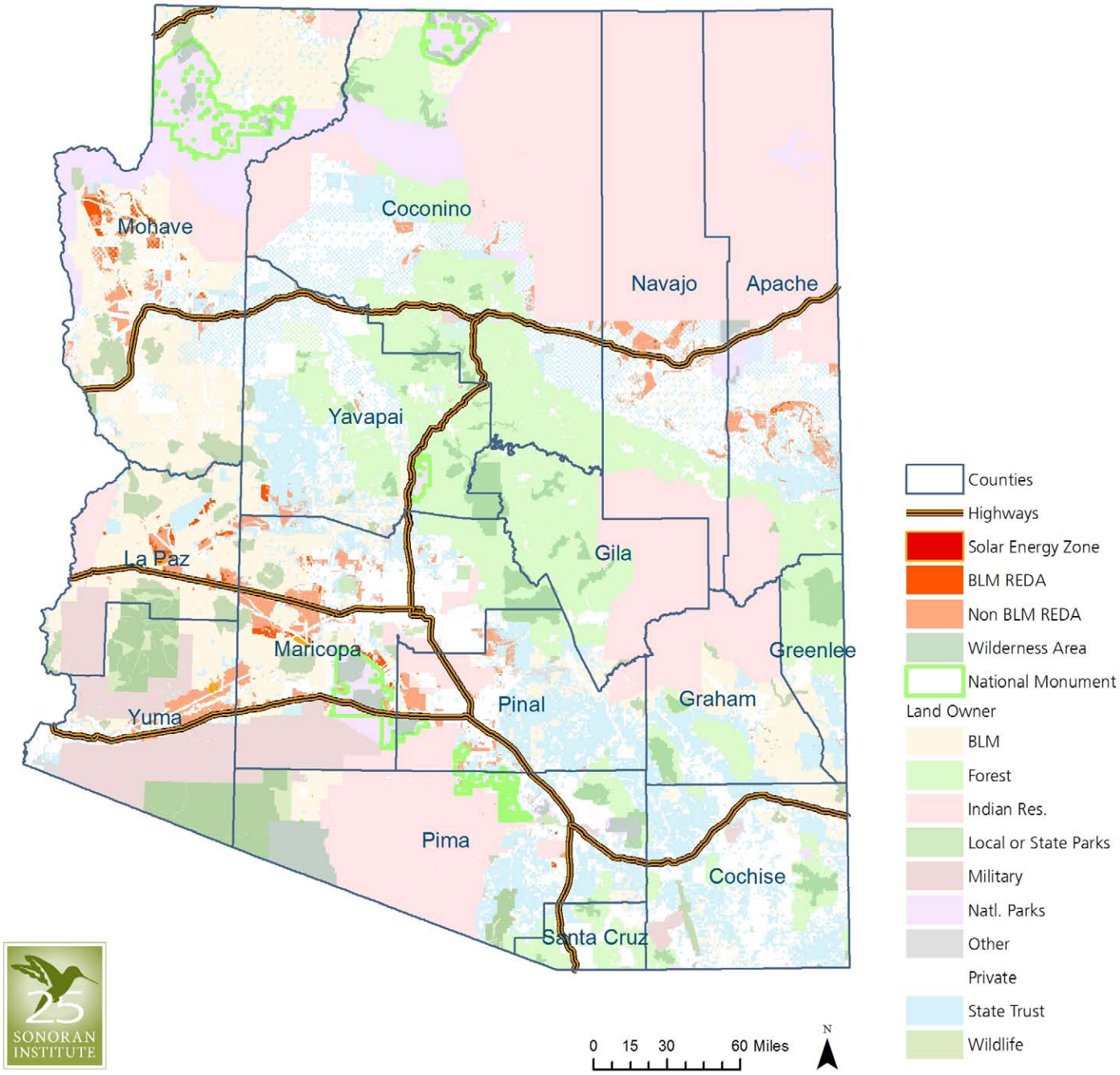


Figure 1. Photovoltaic Solar Resource of the United States



Source: National Renewable Energy Laboratory

Figure 2. Arizona Locations Suitable for Renewable Energy Development



Source: Arizona Bureau of Land Management

A Build-out Scenario for Large-Scale Renewable Energy in Arizona

While a build-out scenario of all of Arizona was considered, this study focuses primarily on western Arizona, which to-date has been the target of most large-scale RE development, primarily solar. Figure 3.1 shows where projects and build-out areas are located. This concentration of RE development is due to the quality of solar resources, the proximity to markets in Arizona and California, the existing and planned transmission capacity, and a diversity of lands suitable for large-scale renewable development. The build-out scenario assumes that those factors will likely continue to influence future development.

The scenario relies on two key elements for its RE generation and carbon dioxide displacement estimates: (1) permitted and planned RE projects; and (2) new projects located in potentially suitable areas.

Permitted and Planned Renewable Energy Projects

There are a number of large-scale solar and wind projects in Arizona that either have completed most of the planning and permitting required or are in the process of doing so. These projects have the potential to be "shovel ready" within two years. Most of these are in western Arizona, but we have included a few projects elsewhere in the state as well.

Table 1 shows the 15 large-scale RE projects that have either completed most of the necessary planning and permitting requirements or are sufficiently advanced in their planning and permitting, but do not yet have power purchase agreements (PPAs) with utilities. These projects have an estimated total capacity of 2,032 MW, with a projected annual generation of 4.5 million MWh of clean energy, and potential annual carbon emission reductions above 2.5 million metric tons.[7] A complete list with detailed project information is located in Appendix B1.

All of these projects are under development by established companies with proven track records in building large-scale renewable generation facilities. However, without PPAs, these projects are not likely to go forward. Once such agreements are secured and all permits obtained, project construction averages about two years before power is generated and delivered to customers. Given these timelines, it reasonable to assume that these projects could meet Arizona's 2022 interim targets under the CPP.

The likelihood that these projects are ultimately built, deliver power, and assist in meeting the CPP's targets for Arizona depends on a number factors, including whether these projects can access existing or planned transmission lines and whether their power is purchased by Arizona utilities. As noted in the previous section, new transmission capacity is being planned to accommodate new RE development in Arizona. This new capacity could accommodate in-state delivery of solar and wind power, but also could facilitate out-of-state shipments, primarily to California markets. This point is worth noting as the companies developing the 15 projects identified could enter into PPAs with California utilities, helping to meet California's CCP targets, rather than Arizona's.

Table 1. Renewable Energy Build-out Study Project List

Project Name	Owner	Capacity * (MW)	Generation (MW/hrs)	CO2 Displaced (Tons)
Aztec	Solar Reserve	13.5	30,500	16,900
AVSE I	Arlington Valley Solar	125	286,300	155,000
Cotton Center 3 & 4	Solar Reserve	40	90,600	50,200
Crossroads Solar	Solar Reserve	150	339,700	188,700
Hyder	Solar Reserve	20	45,300	25,100
Maricopa Solar Park	Marisol Energy	300	679,800	378,400
Mesa Solar	First Solar	50	113,200	62,700
Mini Mesa Solar	First Solar	20	45,300	25,100
Mohave Wind	BP Wind	500	1,078,300	604,200
Octavia Greenworks	Sunpower	195	441,700	245,600
Quartzite Solar	Solar Reserve	100	226,400	125,600
Pima Road	Iberdrola Renewables	48	109,800	59,300
Rainbows	Solar Reserve	20	45,300	25,100
Sonoran Solar	NextEra	300	679,800	378,400
Sun Streams Solar	First Solar	150	339,700	188,700
Totals		2,032 MW	4,551,700 MW/hrs	2,529,000 tons

* Includes PV, CST, and wind

Source: Sonoran Institute

Build-out Areas

The build-out scenario is also composed of eight build-out areas (see figures 3.1, 3.2, and 3.3). Like the permitted and planned projects, these areas are located primarily in central and western Arizona for three important reasons: (1) solar resources are of the highest quality in this part of the state; (2) there is a diverse and extensive land portfolio that can accommodate large-scale RE projects; and (3) these lands are located between two major energy markets (greater Phoenix and southern California) with significant transmission capacity. These factors have played a substantial role in determining the location of large-scale solar and wind projects to date, and will likely continue to do so in the future.

Each build-out area was selected because it includes lands identified through the U.S. Bureau of Land Management's (BLM) Solar Programmatic Environmental Impact Statement (PEIS) and Restoration Design Energy Project (RDEP) as potentially suitable for solar and wind development. RDEP represents the most comprehensive state-wide environmental screening to date for solar and wind projects. Additionally, in an effort to align the assessment with existing transmission and ongoing planning efforts, RDEP only selected areas that were within five miles of existing or certified transmission lines, designated BLM utility corridors, and designated BLM West-wide Energy Corridors.

While designation of Solar Energy Zones (SEZs) through the Solar PEIS and Renewable Energy Development Areas (REDAs) through RDEP does not preclude the possibility of significant environmental impacts within designated lands, in all likelihood, these lands should present lower environmental conflicts relative to other areas. These build-out areas also include state trust lands that the Arizona State Land Department has identified as having high potential for large-scale solar development. Detailed maps of each build-out area can be found in Appendices C-J.

Each build-out area includes at least two contiguous 1,000-acre+ parcels of BLM land designated as either REDAs or state trust lands identified as high priority for solar development.[8] Some of the build-out areas include private lands that are also potentially suitable for solar development, but no private land parcels were identified as these were not subject to any local land-use plan or policy that zoned or designated these private lands for RE development. See Appendix B2 for detailed information.

As part of our build-out scenario, a number of conservative assumptions were made related to RE development within the study's build-out areas:

1. **Acreage available for RE development**
   For BLM parcels, no more than 55 percent of a parcel's acreage is assumed to be developed;[9] For state trust land parcels, which are not typically subject to the same environmental reviews as BLM lands, no more than 75 percent of a parcel's acreage is assumed to be developed.

2. **Build-out area generation capacity**
   The total generation capacity within any build-out area is not greater than 600 MW, with most totaling 300 MW or less. This generation cap is intended to minimize local impacts to the grid resulting from new generation coming on line.[a] As a result, not all parcels within each build-out area are subject to development in our scenario.

3. **Project generation capacity**
   The generation capacity of individual projects is limited to 300 MW, with most sized at 200 MW or less. This is also intended to minimize local impacts to the grid and is comparable with the size of large-scale RE projects that are currently being built. Consequently, not all developable portions of the parcels selected are subject to development in our scenario.

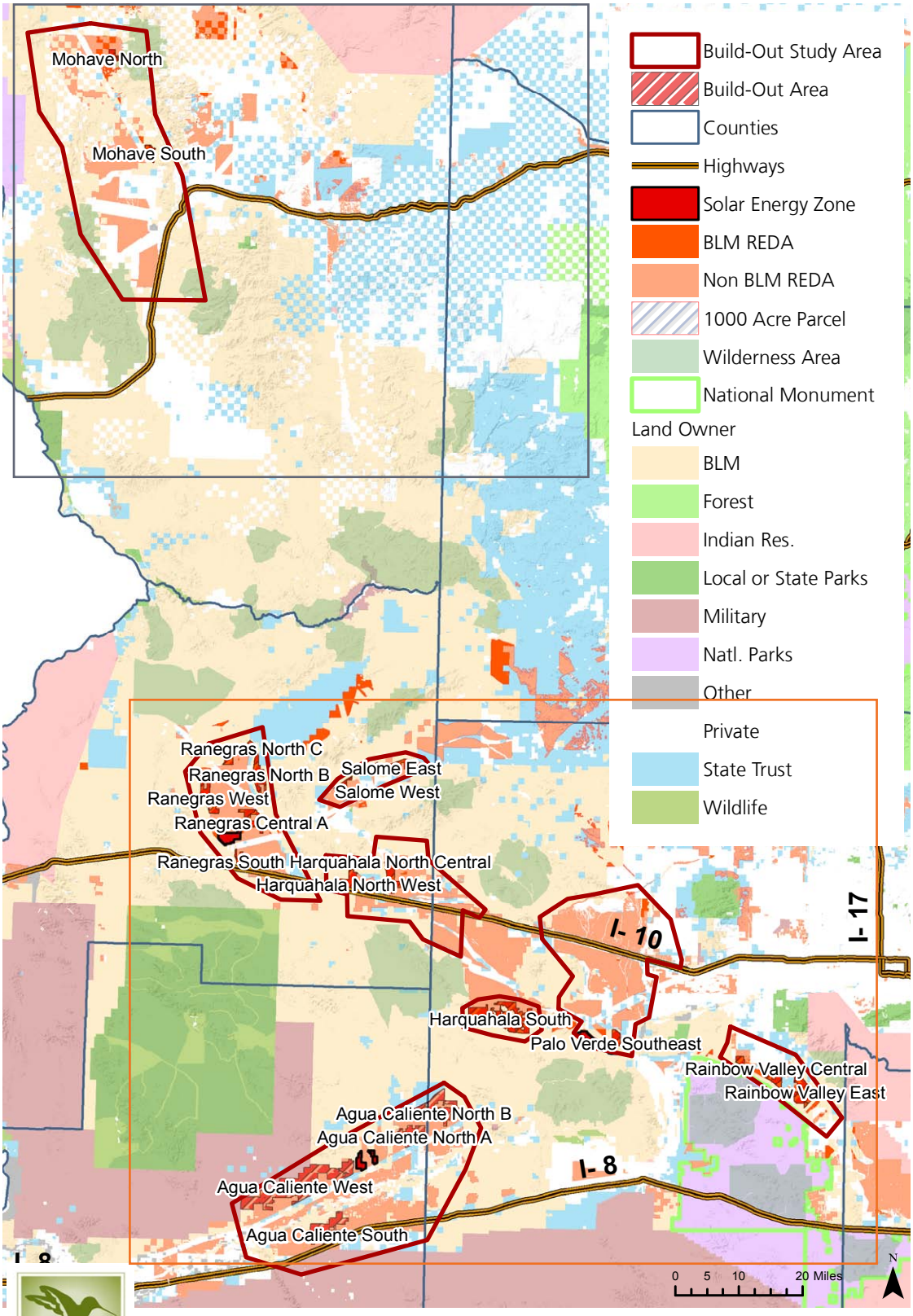
4. **Back-up parcel**
   A "default" parcel is included in each build-out area (with the exception of the Harquahala South build-out area, which is composed of one large, single parcel) that can accommodate another project of similar size. This provides further flexibility in meeting our scenario's RE development targets.

5. **Technology**
   For the purposes of calculations, generation and emissions reductions, all parcels would be subject to solar photovoltaic development.[10, b]

[a] This cap does not reflect any physical or other limitations to development within a build-out area.

[b] This does not preclude the possibility that concentrated solar thermal projects could be located in these build-out areas.

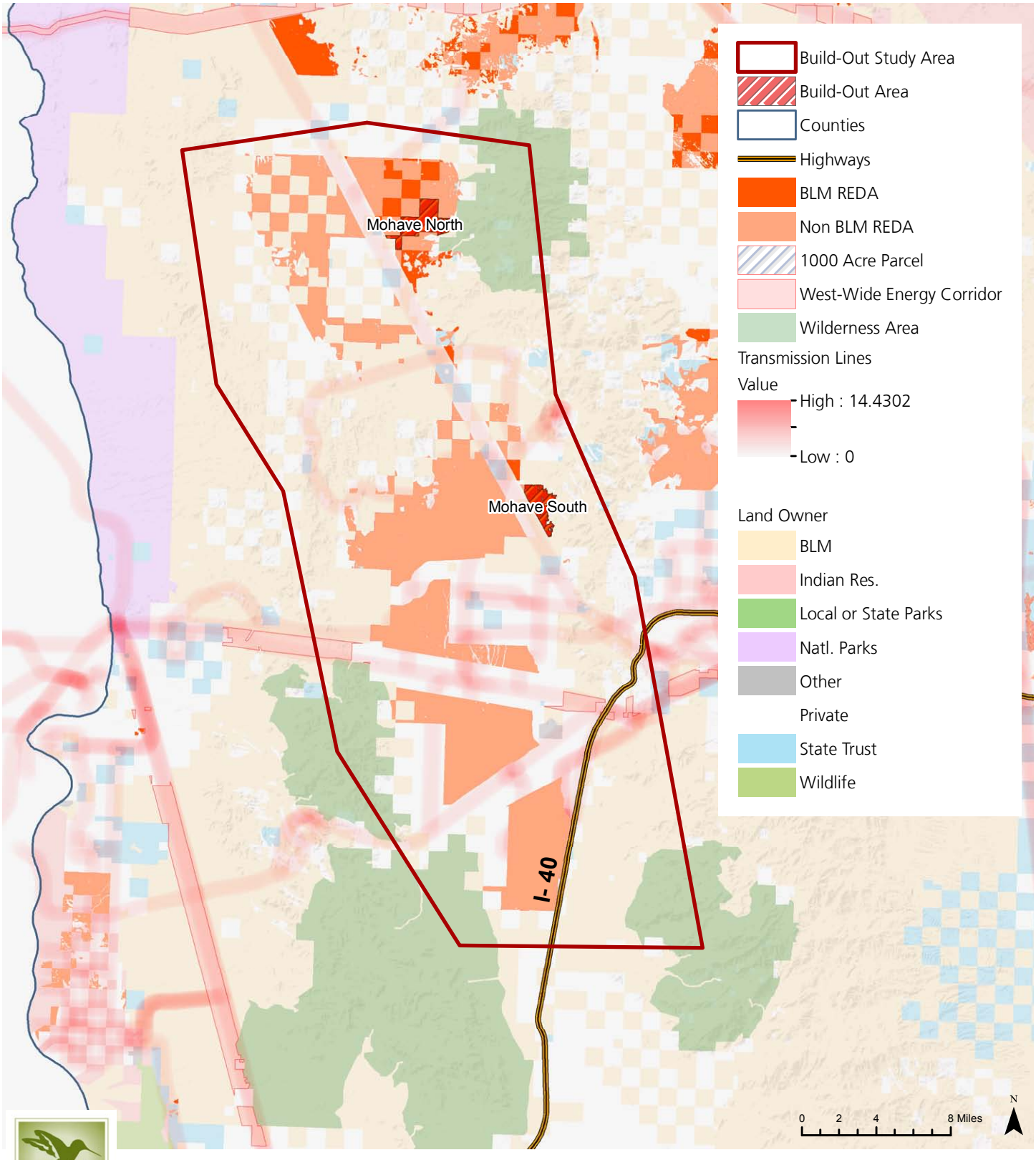
Figure 3.1. Arizona Renewable Energy Projects and Build-out Areas



Build-Out Areas

Source: Sonoran Institute

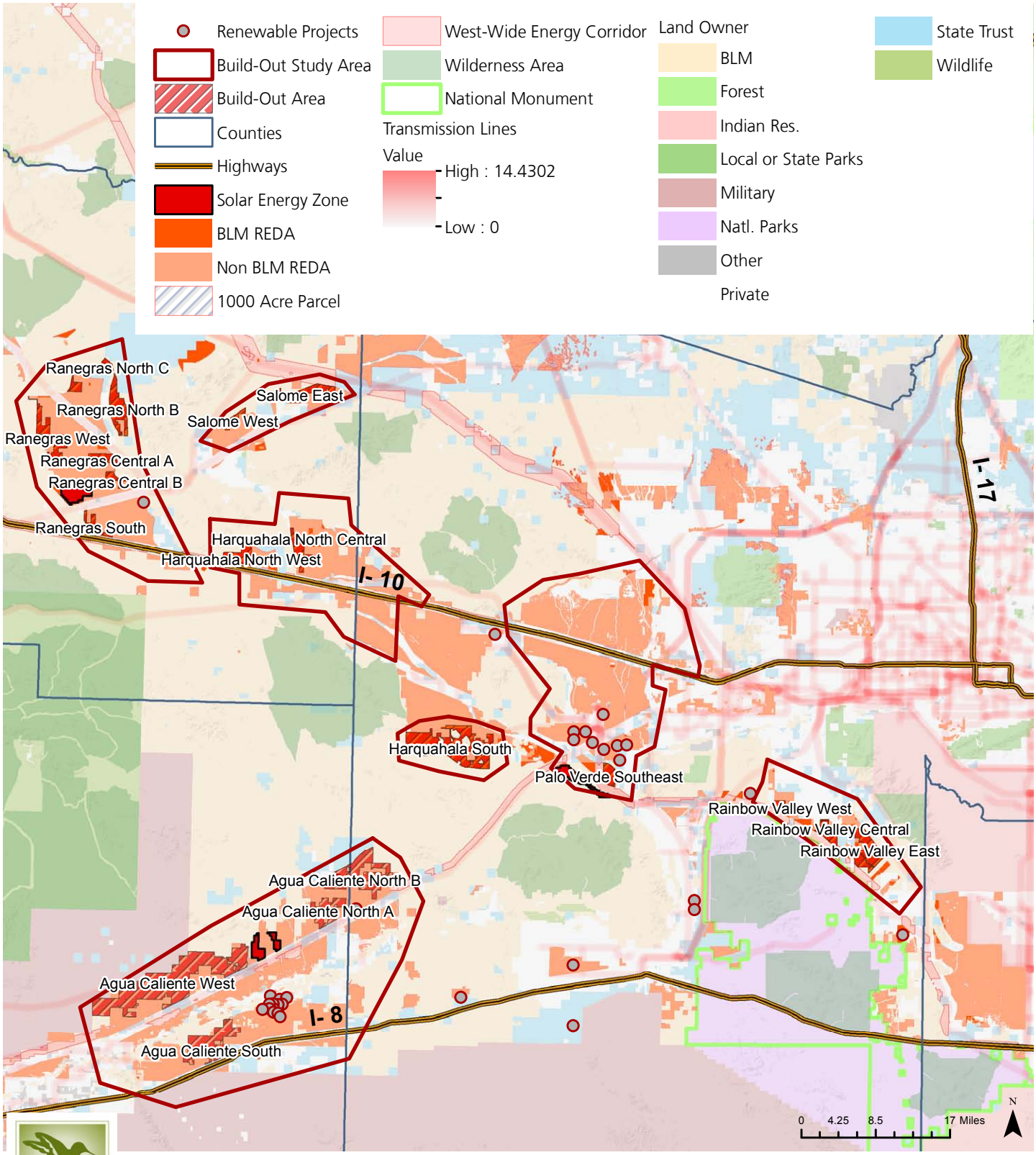
Figure 3.2. Arizona Renewable Energy Projects and Build-out Areas



Build-Out Areas

Source: Sonoran Institute

Figure 3.3. Arizona Renewable Energy Projects and Build-out Areas



Build-Out Areas

Source: Sonoran Institute

As table 2 indicates, development within these build-out areas based on the above assumptions has an estimated total capacity of 2,280 MW. However, to underscore the illustrative nature of the build-out scenario, the 121,144 acres of BLM and state trust lands identified within the eight build-out areas that meet the initial size and screening criteria applied in our parcel selection have a total capacity of 17,306 MW. We are assuming development of less than 15 percent of that capacity. If the parcels used as part of the build-out scenario are not developable, there are other parcels nearby that may be. The opportunities for siting large-scale renewable generation within the build-out areas alone in response to the CPP are significant.

Whether projects are proposed on these parcels and help meet the CPP targets depends on factors similar to those affecting projects already undergoing planning and permitting: access to transmission and securing PPAs. Additionally, while the parcels selected for the build-out scenario have been screened for environmental conflicts and deemed potentially suitable for solar and wind development, these parcels will require additional site-specific analyses once projects are proposed, and some lands ultimately may be deemed unsuitable.

Table 2. Build-out Area Summary

Metric	Amount	Comment
Total Acres	121,144	Total acreage for all 1K+ parcels in build-out areas
Total Capacity (MW)	17,306	Assumes 7 acres per MW
Developable Acres	78,557	Based on developable acreage estimates (55% and 75%) for all 1K+ parcels
Capacity, Developable Acres (MW)	11,222	Assumes 7 acres per MW
Build-out Scenario Acres	63,636	Based on developable acreage estimates for parcels selected for build-out scenario
Capacity, Build-out Scenario (MW)	2,280	See assumptions related to size and number of projects per build-out area (in above text)

Source: Sonoran Institute

New Mexico Wind Imports

One effective way to integrate large amounts of intermittent power into the grid, as contemplated in this study's build-out scenario, is to implement a highly diverse RE portfolio by type of resource and location. For example, pursuing a geographically diverse portfolio of solar and wind takes advantage of the fact that the sun may be shining or the wind may be blowing in certain areas while not in others. This can help reduce some of the fluctuations in energy generated by solar or wind. This approach is particularly ideal when the sources of renewable power are able to complement each other in terms of the time of day and season when they produce energy.

Such is the case with Arizona solar and New Mexico wind. As figure 4 illustrates, New Mexico's daily wind generation tends to peak when Arizona's solar generation drops and vice versa. New Mexico has some of the best wind resources in the southwestern desert. Both its quality and ability to complement the generation profile of the region's solar resources (not only in Arizona, but California and Nevada as well) make it quite attractive to utilities in these states as a way to meet their renewable generation goals and address the intermittency of solar power.

There are at least three transmission projects currently under development seeking to deliver New Mexico's wind to markets in Arizona, California, and Nevada. Figure 5 demonstrates how these lines anticipate tapping into New Mexico's wind resources. All three are in various stages of the planning and permitting process:

- SunZia has completed the federal environmental review process for two single-circuit 500 kV AC lines with a capacity of transmitting up to 3,000 MW of electricity to the Pinal Central substation, and is now seeking to secure state permits and rights-of-way from private and state landowners. The project developer anticipates having at least one line in service by 2020 (SunZia).

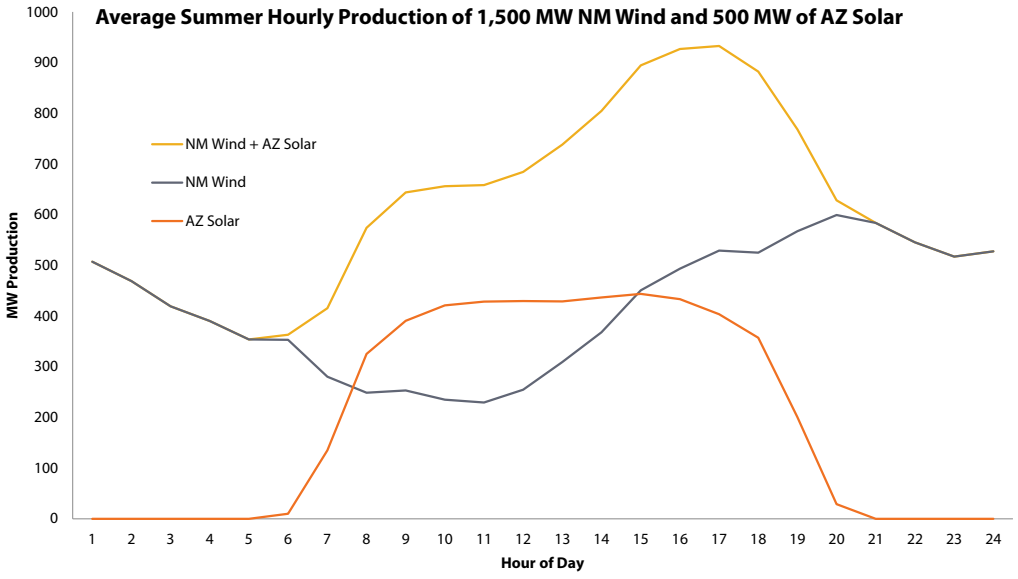
- The Southline Transmission Project involves the construction of a new double-circuit 345 kV AC line and an upgrade of an existing 115 kV facility into a double-circuit 230-kV AC line, providing capacity of up to 1,000 MW to the Saguaro/Tortolita substations. The project is anticipating completion of the federal environmental review process in 2015. The project developer expects the line to be operational by 2018 (Southline Transmission Project).

- Western Spirit is being developed jointly by Clean Line and the New Mexico Renewable Energy Transmission Authority. It does not require federal environmental review and is currently seeking to secure state and local permits and rights-of-way from private, state, and tribal landowners. This project consists of a 345-kV double-circuit AC line, providing a capacity of up to 1,500 MW of transmission capacity to the Four Corners substation. The project developer anticipates its line to be operational by 2018 (Western Spirit Clean Line).

From the standpoint of the CPP, New Mexico's wind resource gives Arizona flexibility to achieve emissions reductions with a diverse portfolio, while relying less on natural gas. Given its complementary nature, it may also address some of the challenges of integrating larger amounts of solar into the grid, as this study's build-out scenario contemplates.

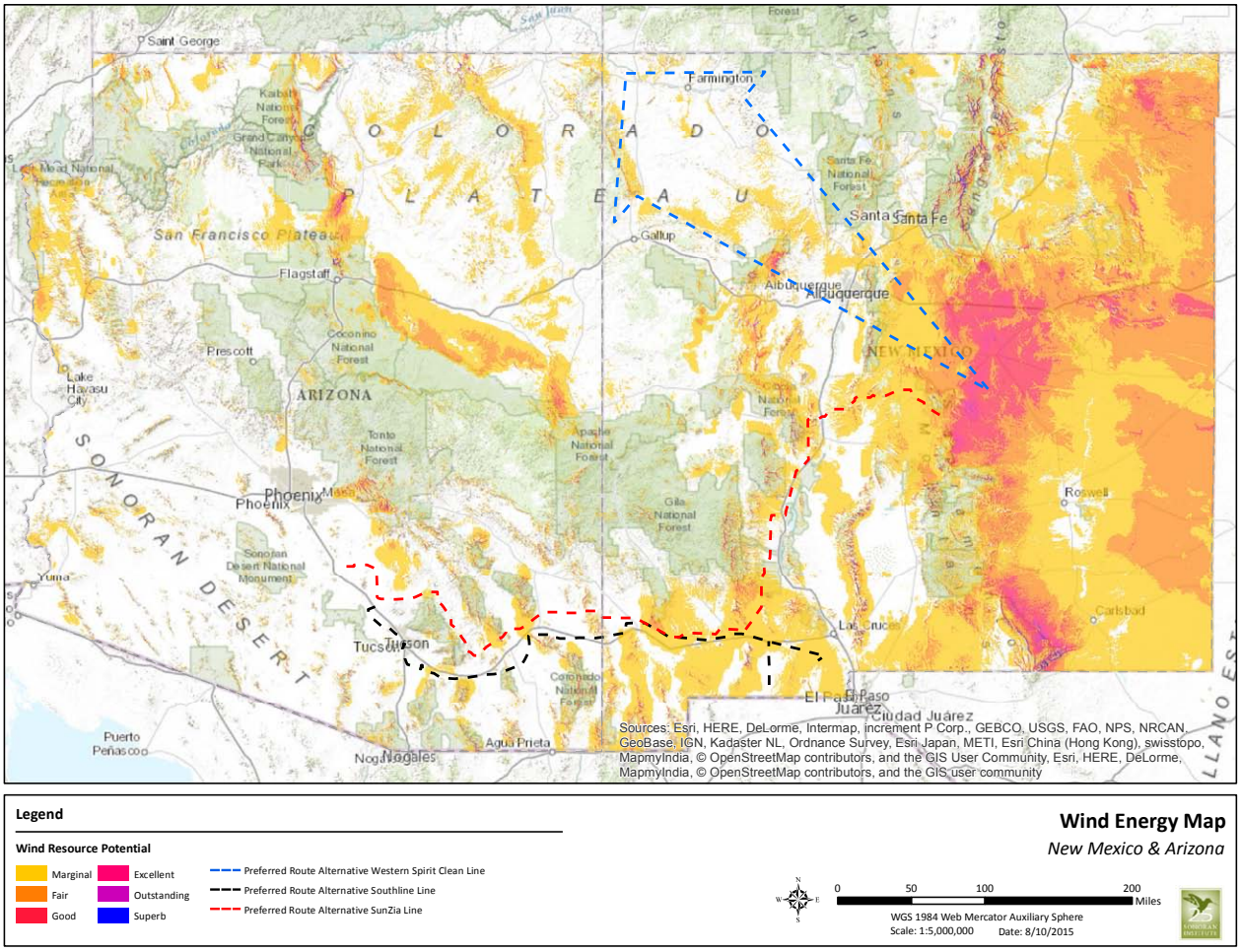
How much New Mexico wind will be available and needed in response to the CPP or to support the build-out scenario depends on a number of factors, including the timing and amount of wind delivered through any of these lines and the extent to which this power is purchased by Arizona utilities. However, given where these three projects are in the planning and development process, it is reasonable to assume that at least 1,000 MW of wind could be available to Arizona by 2020.

Figure 4. New Mexico's Wind Generation Complements Arizona Solar



Source: Sun Edison

Figure 5. Potential Transmission Lines Can Capitalize on New Mexico's Wind Resources



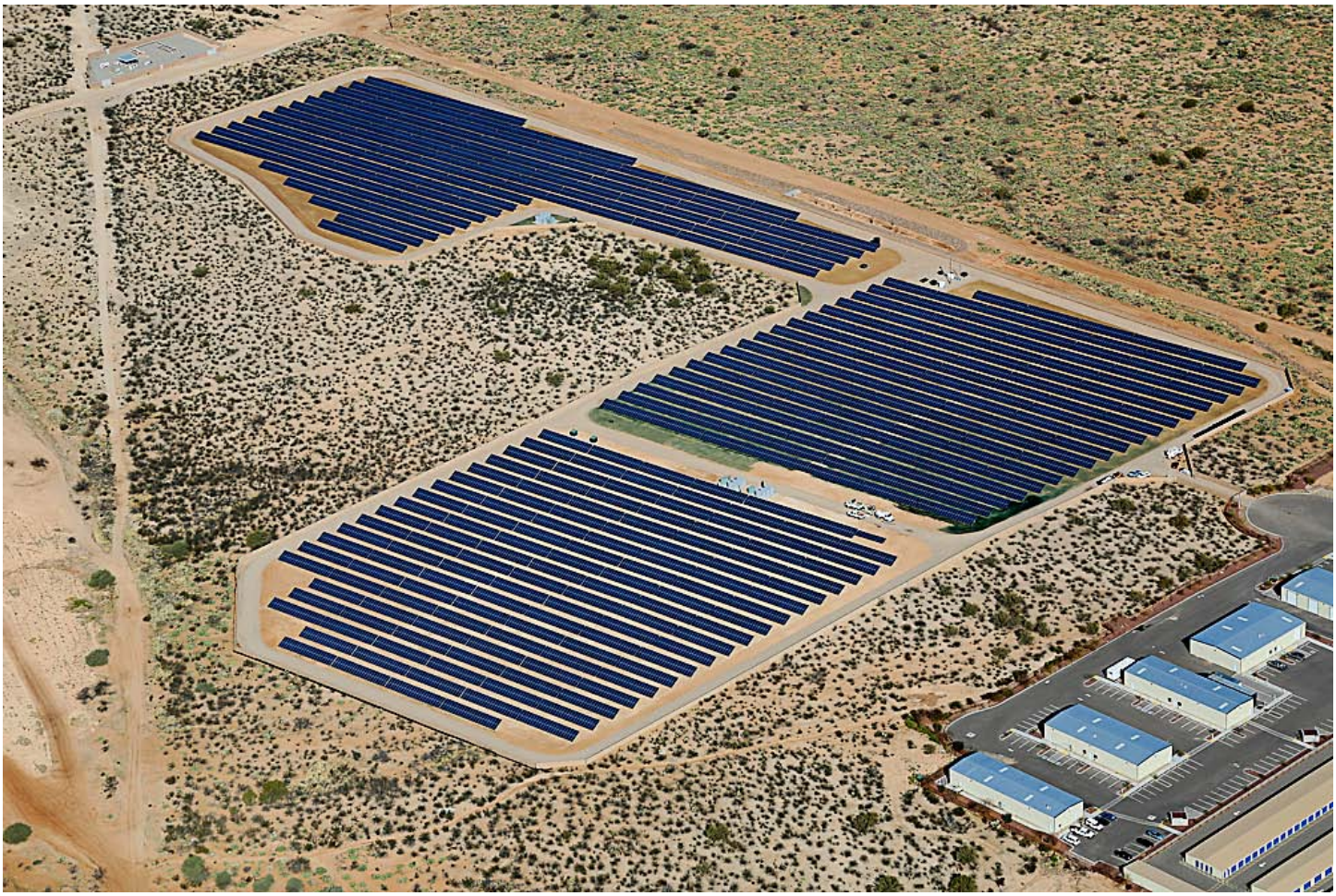
Source: Esri et al. above

The Build-out Scenario and the Clean Power Plan

As one possible, partial response to the CPP, this study's build-out scenario outlines a two-phased implementation strategy for large-scale renewable energy that could help meet the CPP's interim and long-term carbon reduction targets. In the short term, there are 15 permitted and planned RE projects with a capacity of 2,032 MW that could realistically be operational by 2022, the plan's interim deadline. Some of these projects could be up and running in less time than that.

In the long term, there is a diversity of parcels that could accommodate new projects that might be built by 2022 but, more likely, in the years that follow and within the CPP's overall timeframe. There are steps being taken, and further steps that could be taken in the near term, to assess their suitability and encourage development where appropriate. In total, the build-out scenario contemplates 4,312 MW of new RE generation.

Overall, the build-out scenario illustrates the additional options for meeting the CPP's targets beyond those assumed by the EPA in its draft rule or in response to current state policies designed to encourage RE development.



Prairie Fire Solar Array

Considerations for Federal and State Decision-Makers

As we have demonstrated, there is undoubtedly significant potential for RE resources to be developed in Arizona or neighboring states to serve Arizona's electricity needs. However, this potential does not guarantee that these resources will be developed. Two important sets of factors will ultimately determine how much and how fast these resources are developed: (1) policies that drive demand for large-scale RE resources among Arizona utilities; and (2) factors that facilitate or constrain the development of large-scale projects (i.e., supply).

Policy Drivers of Demand for Utility Scale Renewable Energy Projects in Arizona

In Arizona, many potential RE projects have progressed through various stages of development, including land acquisition and permitting, but have not been fully developed due to lack of demand from utilities. In general, it is unlikely that any RE project will move forward without a formal commitment from a utility to procure RE either through a power purchase agreement or direct ownership. As another possibility, RE could theoretically be developed as a merchant project without an identified utility purchaser and with the intention to sell energy directly on the wholesale market. In fact, First Solar's Barilla facility in Texas recently became the first merchant solar project to be developed in the U.S. (Roselund 2014). However, we do not anticipate that this approach will be easily replicated in Arizona due to the lack of an organized market. Ultimately, utility demand for RE (and thus policies that stimulate greater demand) is a fundamental requirement for RE build-out to take place. This section discusses potential policies that could drive utility demand for RE development in Arizona.

1. **Renewable energy procurement targets**
   Historically, most of the large-scale RE that has been developed for delivery to Arizona utilities has been driven by the state's Renewable Energy Standard (RES) (Arizona Corporation Commission). This policy was adopted by the Arizona Corporation Commission (ACC) in 2006 and requires investor-owned utilities (IOUs) to acquire 15 percent of the energy serving their customers from renewable sources by 2025 (Arizona Corporation Commission 2006). The state's largest IOUs, Arizona Public Service and Tucson Electric Power, are on track to meet or even surpass these requirements (Arizona Public Service 2015; Tucson Electric Power Company 2015). While some additional RE may be needed to satisfy RES requirements, it is not anticipated that these needs will be large in the near term.

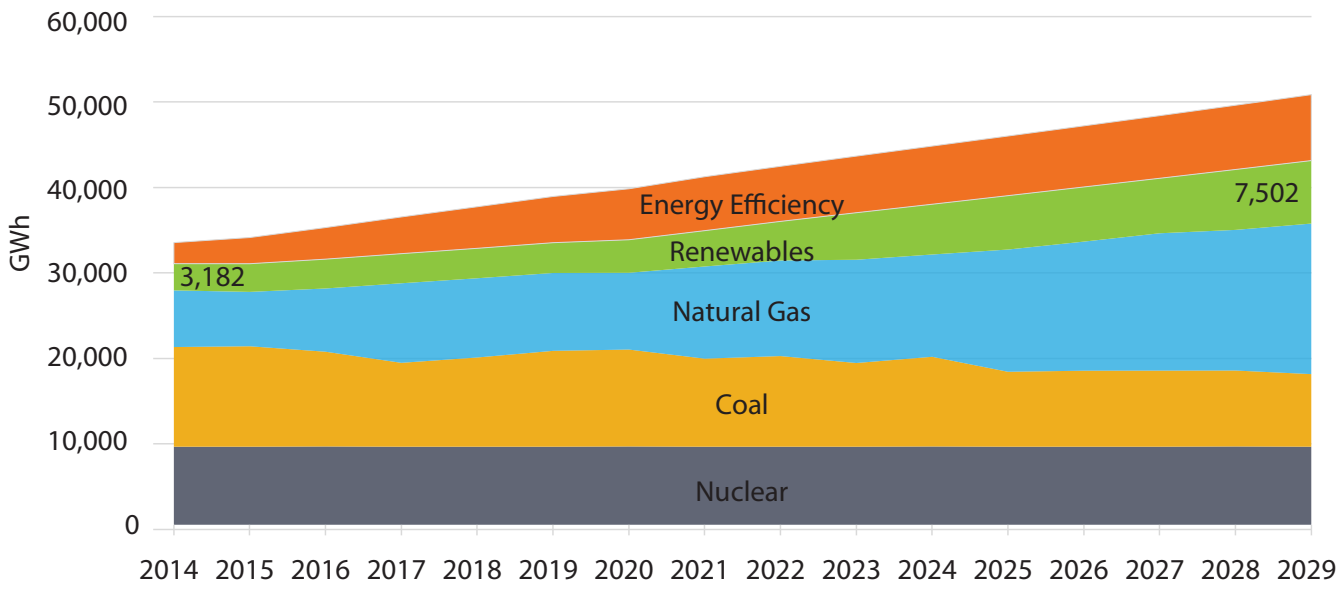
   In addition to the RES, the ACC has at times ordered other requirements for utilities to procure RE resources. A clear example of this was in Arizona Public Service Company's 2009 rate case, which established an accelerated RE procurement target of 1.7 million MWh by 2015 (Arizona Corporation Commission 2009).

   Arizona's second-largest utility, Salt River Project (SRP), is not regulated by the ACC and is not subject to the RES requirements. However, SRP's board of directors has adopted a set of Sustainable Portfolio Principles (SPP) that set a goal of 20 percent of retail energy from "sustainable sources" by 2020 (Salt River Project). SRP's definition of sustainable sources includes not only new RE, but also energy efficiency and existing hydro. The extent to which SRP selects RE to satisfy its SPP goals could drive new RE development.

2. **Integrated resource planning**
   Once the RES and SPP requirements have been met, RE resources may still be sought and procured by Arizona utilities through their standard resource planning processes. In general, all of Arizona's major utilities develop long-term resource plans that forecast energy and capacity needs, and identify the existing and future resources that will be used to meet those needs. Power plant retirements, load growth, and new regulatory requirements are key drivers that may lead utilities to include incremental new energy resources, including RE, in their resource plans. Resource plans consider the company's energy mix when determining how to meet future needs. Figure 6 shows APS's 2014 energy mix.

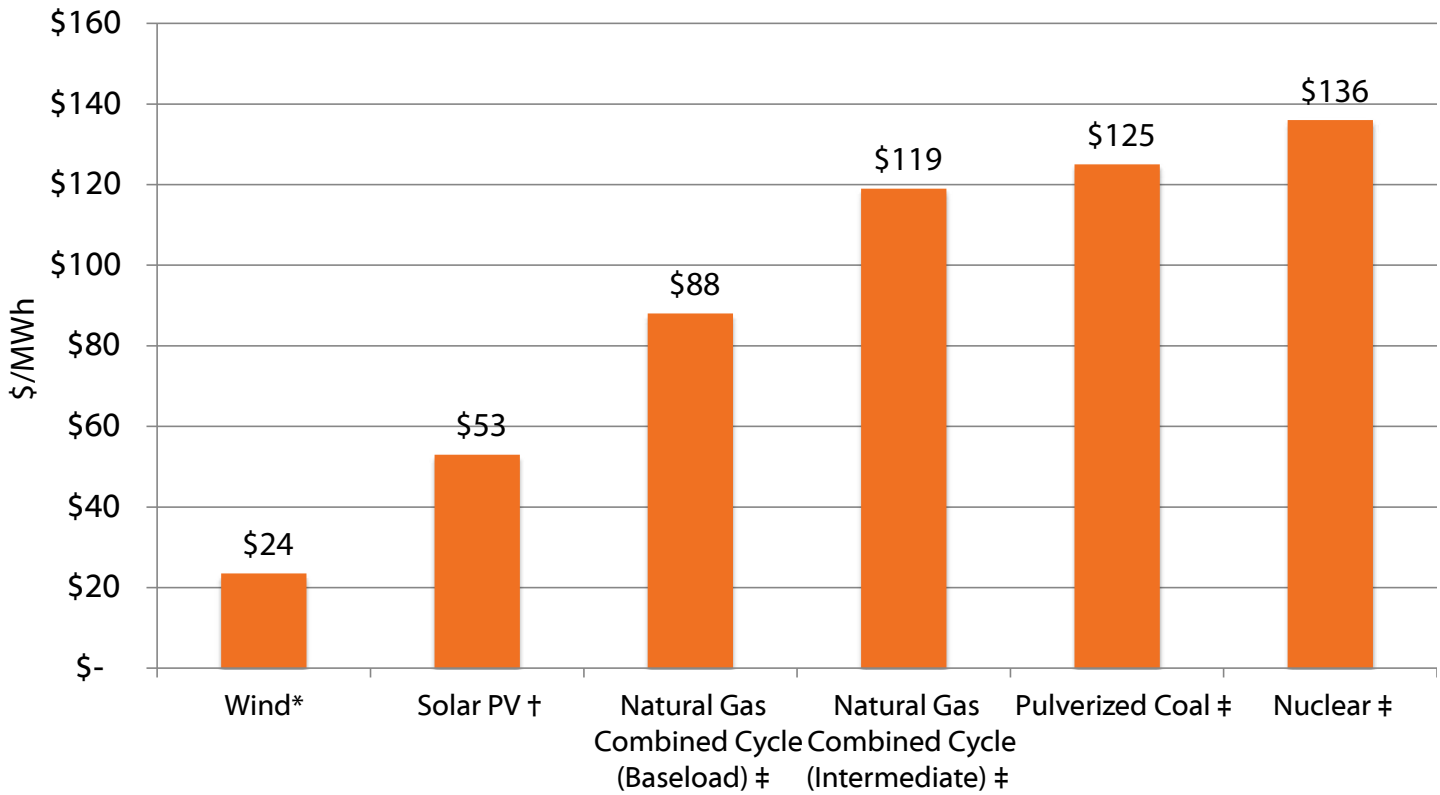
   Over the last several years, significant and steady declines have occurred in the cost of RE technologies, particularly wind and solar (Figure 7) (Barbose and Darghouth 2015). Reductions in technology costs have caused RE resources to become increasingly cost-competitive with conventional resources, improving the viability of RE to be included in utility resource plans, even in the absence of additional procurement targets (e.g., RES).

Figure 6. APS 2014 IRP Energy Mix (GWh): Selected Portfolio



Source: APS 2014 IRP, Attachment F.1(c)(1) - Current Path Scenario, p 329

Figure 7. Levelized Cost of Energy for New Construction



* Average levelized long-term price from wind power sales agreements signed in 2014 (data from Lawrence Berkeley National Lab).

† AZ cost estimate based on recent PPA price for SRP Sandstone Solar PV Project (45 MW) executed in 2014.

‡ AZ cost estimates based on Tucson Electric Power's 2014 IRP.

Source: Lawerence Berkeley National Lab

Utilities under the ACC's jurisdiction are required to file a detailed Integrated Resource Plan (IRP) every two years (Arizona Secretary of State 2013). These plans are reviewed by the ACC. The ACC acknowledges when an IRP has met all the filing requirements by issuing a Final Order. The most recent plans were filed by utilities in 2014 and acknowledged by the ACC in 2015. Some of the IRPs filed in this cycle considered high RE portfolios that significantly exceeded the RES requirements, but these were ultimately not selected. For the 2016 plans, the ACC has adopted certain changes to the IRP process (Arizona Corporation Commission 2015):

- Greater emphasis on 3 year Action Plans, including the possibility for ACC approval versus acknowledgement
- Potential pre-filing workshops conducted by the ACC
- Requirements for utilities to submit information on the costs and benefits of new technologies
- Recommendation that the next IRPs consider expanded RE scenarios

Additionally, the ACC is contemplating a revised timeline to allow utilities time to respond appropriately to the Clean Power Plan.
SRP does not provide a similarly detailed IRP to the public in the same manner as Arizona's investor-owned utilities. However, SRP is required to submit a more limited IRP since it is a customer of the Western Area Power Administration (WAPA). The most recent IRP, SRP submitted to WAPA was in 2012. Overall, these changes improve the likelihood that more RE will be incorporated into future IRPs.

Impact of policies in neighboring states

In addition to policies that Arizona sets, those of nearby states may also have a significant influence on demand for RE projects that are developed in Arizona. For instance, several of Arizona's largest solar photovoltaic (PV) projects were developed for delivery to California utilities as a means of meeting California's Renewable Portfolio Standard. These projects include First Solar's 290 MW Agua Caliente project, LS Power Group's 125 MW Arlington Valley project, and Sempra US Gas and Power's 150 MW Mesquite project. While California's RPS has driven demand for RE in Arizona to some extent, the state subsequently made revisions to its policy in California Senate Bill X12 placed certain restrictions on RE from other states, thereby limiting demand for Arizona RE projects (California Senate Bill X12 2011). However, as California pursues more aggressive RPS targets (legislation has passed the state house and senate, setting a 50 percent target by 2030), the likelihood of importing RE from other states increases. Also, the California Energy Commission and California Public Utility Commission are launching a Renewable Energy Transmission Initiative (2.0) that may take a multi-state approach to identifying the most appropriate locations for large-scale RE generation and transmission to meet the state's targets.

3. The Clean Power Plan

The CPP is a potential new policy driver that could create additional demand for RE in Arizona, either for local needs or for utilities in other states. The final rule sets final CO2 emissions guidelines of 1,305 lbs/MWh for fossil steam units and 771 lbs/MWh for natural gas combined cycle (NGCC) units. Currently, Arizona's electricity generation facilities include coal steam units that average 2,268 lbs/MWh and NGCC units that average 900 lbs/MWh (U.S. EPA 2015a). The EPA rule identifies many possible pathways for compliance, and states have discretion in determining which of these paths to choose. One option clearly identified in the rule is for electricity generation facilities that exceed the emissions guidelines to come into compliance by acquiring emissions reduction credits from RE resources in Arizona. These credits would be applied to the units' reported emissions rates, helping the units come into compliance with the CPP's emissions guidelines. For example, a fossil steam unit producing 1,000 MWh at 2,000 lbs/MWh could meet compliance by obtaining credits produced from 533 MWh of RE.[11]

The need to obtain emissions reduction credits could therefore drive demand for additional RE development in Arizona as well as other states since electricity generation facilities will increasingly need more to meet compliance targets. Notably, the EPA's final rule appears to place very few limitations on where the credits must originate. Thus Arizona's RE resources could potentially be used to serve a variety of external needs, not just those of utilities within the state. Planning for and implementation of the rule by states will occur over the next several years, making it difficult to estimate any increased RE demand in Arizona driven by the CPP.

Factors That Might Facilitate or Constrain Renewable Energy Project Development in Arizona

In the event that overall demand for Arizona's RE resources increases, there are several factors that may serve to accelerate or impede the development of individual projects. In this section, we discuss some of these factors, including: availability of appropriate land, permitting requirements, interconnection requirements, grid integration needs, available transmission, and utility procurement practices.

1. **Availability of appropriate land**

   As demonstrated earlier in this paper, there is substantial available and appropriate land in Arizona for RE project development. The RDEP process alone identified 192,100 acres of BLM lands and more than 1.6 million acres of non-BLM lands (including U.S. Forest Service, state trust, and private lands) as potentially suitable for solar or wind development. Additionally, as noted earlier, the RDEP process only selected areas that were within five miles of existing or certified transmission lines, or designated BLM utility corridors. Since the parcels selected for this build-out study were based on the RDEP process and also fit these criteria, we conclude that a significant quantity of land, near transmission, is available for RE project development.

2. **Permitting requirements**

   Significant efforts have also been made in recent years to facilitate RE development on federal, state trust, and private lands through various planning and policy initiatives.

   Through the Solar PEIS and RDEP, the BLM is proactively identifying and preliminarily screening parcels and developing additional policies to incentivize development on these lands. These efforts led to the successful auction and approval of three solar energy projects within a Solar Energy Zone in Nevada that will generate up to 440 MW of energy. Additional incentives for locating in these zones will be provided through a rulemaking effort that is currently under way to revise the BLM's process for leasing parcels for RE project development (Bureau of Land Management 2014).

   In addition to leasing practices, an important financial consideration for development of public lands is the need to conduct any mitigation for environmental degradation. BLM in Arizona is currently developing a regional mitigation strategy to identify likely unavoidable impacts associated with solar development and quantify the costs to developers to mitigate them (Bureau of Land Management). Ultimately, the goal of this quantification would be to set a per-acre fee as a guide for project developers and ideally will provide more certainty on the environmental costs of these projects.

   The Arizona State Land Department (ASLD) has performed its own evaluation of state trust lands and identified lands on a scale of low to high potential for large-scale solar development. ASLD was among the first state agencies in the West to develop a solar lease program and secure a lessee for solar energy development. It has also worked with the BLM and private property owners to develop a wind project that extended across all three ownerships.

   At the local level, the Town of Gila Bend, Arizona has been recognized as a leader in solar development due to its adoption of Solar Field Overlay Zone (Town of Gila Bend 2012). This zoning overlay has enabled an accelerated permitting process that substantially reduces the time for permitting utility-scale solar projects from years to weeks. These practices have contributed to over 340 MW of solar being developed in the Gila Bend area, predominately on private lands that were previously used for agriculture. Similar practices could be adopted in other jurisdictions to help minimize the time necessary to develop solar projects.

3. **Interconnection requirements**

   In addition to a PPA, large-scale RE project developers must usually secure an interconnection agreement with the transmission owner to which the project will be physically connected. (Securing an interconnection agreement is a major project development milestone that typically precedes signing a power purchase agreement.) As required by the Federal Energy Regulatory Commission (FERC), every transmission owner's open access transmission tariff (OATT) must include a procedure for processing large and small generator interconnection requests.

All Arizona transmission owners, which are most often utility companies, have established interconnection queues to allow interconnection requests and related studies to be processed in an orderly and sequential manner. These studies are generally carried out by the transmission owner, and completed according to the sequence of the interconnection queue.

Project developers seeking interconnection can submit their projects to be included in the transmission owners' interconnection queue. In fact, in Arizona, many large-scale RE projects are already in queue, and some have even had interconnection study work completed. As of August 2015, the queues of transmission owners include four interconnection agreements for APS, nine for SRP, six for Western Area Power Administration, and one for UNSE, TEP's sister company (see Appendix K). The total maximum capacity for all 20 interconnection agreements is 3,652 MW (WestConnect).

4. Available transmission

iStock Image

In the short term, delivery of RE cannot occur unless the RE project is able to secure transmission capacity from the owner of the transmission network to which the project is interconnected. Specific transmission corridors or "paths" on the system may have more or less available transmission capacity (ATC). Limitations on ATC may in turn restrict the amount of RE that can be developed in a certain location on the grid. Each transmission owner provides information on ATC through its OASIS website[12] and allows outside parties to request transmission services.

Over the long term, transmission network expansion may be necessary to accommodate additional resources added to the system, including RE. The implementation of FERC Order 1000 by regional planning entities is intended to ensure that this expansion occurs in an effective and efficient manner. Under Order 1000, regional transmission plans must include projects necessary for reliability, and economic and public policy purposes. Under this framework, the CPP represents a public policy that may necessitate incremental RE resources, and in turn new transmission lines. All of Arizona's utilities are members of WestConnect,[13] which is responsible for carrying out the regional planning process under Order 1000. There are four regional planning entities in the Western Interconnection, all of which rely on information and data from Western Electricity Coordinating Council[14] (WECC) to conduct planning activities. WECC has developed long-term transmission expansion scenarios that incorporate potential changes in transmission network due to technological changes and policies like the CPP (WECC).

5. Grid integration needs

An increasingly important topic for utilities and regulators to consider in future RE procurement processes is whether RE projects should be incented or required to provide ancillary services. Ancillary services such as reactive power, frequency response, and energy imbalance services are critical for reliable operation of the bulk electric system. Traditionally, these services have been provided by conventional power plants. As RE penetration increases on the system, there may be a growing necessity for new RE projects to provide these services, or to ensure that the system as a whole can continue to provide them through other means. The next section discusses RE procurement practices in more detail.

Many have posited that higher penetrations of wind and solar may increase the need for other types of services beyond those needed to maintain existing electric system capabilities. For example, additional variable generation (e.g., wind and solar) may increase the need for system operators to carry greater operating reserves to account for the uncertainty. In 2012, APS commissioned a study to estimate the incremental cost of reserves needed to integrate solar in the future (Black & Veatch 2012). The study found that increased cost of reserves could reach about $3/MWh in 2030 (or about 0.3 cents/kWh). It should be noted that the cost for some of these services could be significantly reduced through market enhancements, such as the recent formation of the Western Energy Imbalance Market.

6. RE procurement practices

Utility-scale RE projects located in Arizona have been successfully procured by utilities both in Arizona and neighboring states. Multiple procurement models have been used in the state. The most common of these is a power purchase agreement (PPA) in which a utility contracts to purchase power from a developer for a set period of time. In less frequent cases, utilities have been granted approval to build and own RE projects themselves[15] and incorporate these into their rate base. This was true of APS' AZ Sun program, in which 200 MW of solar procurement was authorized by the ACC in 2009 (Arizona Corporation Commission 2012).

In February 2015, the ACC conducted a workshop that in part explored best practices for procurement. Some recommendations provided by participants were as follows:

- Minimum bid requirements for competitive procurement
- Require 1-year notice to bidders
- Provide clarity on what is being valued
- Have independent consultants examine resource needs and resources eligible to bid
- Consideration of market tests when costly options are presented in IRPs

Modern wind and solar technologies are also capable of providing certain ancillary services (these are discussed in greater detail below). However, utilities have not frequently asked for these technologies or volunteered to provide compensation for them. The terms of compensation for ancillary services is established in each utility's open access transmission tariff (OATT), as required by FERC.

Since RE projects may be difficult or costly to retrofit after they are built, it may be sensible to explore the possibility of including ancillary service capabilities on all or a portion of new RE projects that are developed. The first step in this process would be to establish a process to independently determine or verify the need for specific ancillary services on the system – including their magnitude and location.

As the transition to RE moves ahead in Arizona and other states, decision-makers may want to consider new means of procuring ancillary services. For example, as FERC recently suggested:

> "A transmission provider could use competitive solicitations to target the potential retirement of generation capacity due to economic conditions or environmental regulations that could result in a system need for reactive power at specific locations on the grid in the near future. In that case, the transmission provider could specify reactive power needs in terms of quantity, availability, type (static or dynamic) and location and all providers of reactive power (i.e., generators, transmission equipment, demand response, storage, transmission lines) could submit bids to supply those particular needs." (Federal Energy Regulatory Commission 2014, 22).

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Grid Reliability Impacts and Benefits of RE Build-out

Overview

Power system planners and operators have developed an extensive number of standards and practices to ensure the reliability of the bulk electric system. Traditionally, the concept of reliability has been based on achieving two principal outcomes: adequacy and security. Conventional power plants have provided a suite of essential reliability services to ensure these outcomes. Now, the prospect of transitioning toward a greater penetration of RE under the Clean Power Plan raises many questions about the implications for reliability. In this section we explore some of these concerns and how changes might impact the ability of the system to continue providing essential reliability services.

1. **Adequacy**

   Adequacy primarily addresses the question, "Is there enough energy generation on the system to meet demand?" Generation resource adequacy is typically studied using probability to understand the likelihood of an outage while accounting for the chances of generators being offline during peak load conditions. As a rule of thumb, system planners often seek to have enough generation capacity on the system to maintain a reserve margin of 15 percent of peak demand. Another metric often used is "loss of load expectation" (LOLE), whereby planners strive to keep the probability of not having enough generation to less than one day in 10 years. One concern about RE resources is that their output is variable and uncertain and may not always perfectly match peak load conditions. Moreover, RE output requires a somewhat different approach to resource adequacy. The variability and uncertainty can be managed. Better techniques for forecasting RE output can help minimize uncertainty and also reduce the need for system operators to carry expensive operating reserves necessary in the event that RE is unavailable. A diverse mix of RE generators over a wide geography can also minimize variability and ensure overall capacity needs are met.

2. **Security**

   Security primarily focuses on the question, "What happens to the system after a disturbance?" This involves studying the system after a contingency (or "N-1" condition) whereby a generator or transmission line is taken offline during specific system conditions (e.g., a heavy summer peak load, or a light spring low-load condition). Security studies can be static in nature (i.e., steady-state) or dynamic (i.e., transient stability). In transient stability, major concerns include frequency response and voltage control.

Essential Reliability Services and Provision of These Services by Renewable Energy

1. **Reactive power and voltage control**

   Reactive power and voltage control are critical components of reliable operation of the AC power system. The provision of reactive power is necessary to allow real power to be delivered and to reduce line losses. Furthermore, the ability to control reactive power can help mitigate transient instabilities (e.g., rotor angle and voltage instabilities) (Vittal et al. 2012). However, reactive power cannot be transported over long distances. Some potential sources of reactive power include:

   - Synchronous machines (e.g., fossil generators, synchronous condensers)
   - Capacitor banks
   - Modern asynchronous generators (e.g., wind and solar plants)

   Early forms of wind and solar did not provide voltage control and only absorbed reactive power from the transmission system. However, newer RE plants often include advanced inverters that can be operated in "reactive power mode." In fact, according to FERC, solar PV plants have significant reactive power capabilities. For example, "If inverter is oversized to 110% of generator capacity then system can supply 46% reactive power at 100% of real power output (0.91 leading/lagging) and 110% reactive power at 0 real power output" (Federal Energy Regulatory Commission. 2014, 5). Moreover, solar PV plants can theoretically be operated in STATCOM mode whereby the inverters provide voltage control even at nighttime (North American Electric Reliability Corporation 2012). Solar thermal plants typically operate as synchronous machines, similar to conventional steam turbines, and can provide the same reactive power and voltage control.

System planners and regulators are concerned that power plants currently serving as sources of reactive power for Arizona could be retired or replaced due to the Clean Power Plan. This may require new sources of reactive power to be added to the system, or existing sources to be utilized more effectively. RE plants can be designed to provide reactive power; however, increasing this capability is much less expensive when the generator is initially designed than it is to retrofit later. As more RE is brought online, it is paramount for system planners and regulators to identify opportunities to include reactive power capabilities in new RE projects and target these capabilities to areas of highest need.

2. Frequency response

Another important reliability service is frequency response. If load increases on the system or a generation outage occurs, frequency will begin to deviate from its nominal 60 Hz. If the frequency deviates too far, it can lead to equipment damage and cascading outages.

Synchronous machines such as conventional steam turbines that have inertia due to their spinning mass automatically begin to arrest frequency declines within a few seconds. While modern wind and solar PV plants do not have inertia that is perfectly analogous to conventional plants, they can be designed to provide frequency response through power electronics that is equal or better than conventional plants. In wind plants this can be accomplished by using inertia from rotating wind turbines to temporarily increase output and provide fast frequency response in a 5- to 10-second time frame. Solar PV plants have no inertia; however, they can still be configured to provide fast frequency response if their output is pre-curtailed. This response is almost immediate. Solar thermal plants have synchronous machines that operate similarly to conventional steam turbines and can provide the same type of frequency response.

Reliability Studies Related to the Clean Power Plan or Increased Penetration of Renewable Energy

In recent months, numerous studies have been conducted in the western U.S. to address different aspects of the same question: "What could more RE and less coal mean for the reliability of the bulk electric system?" In this section we review some of the studies relevant to Arizona that have been conducted.

1. SWAT coal reduction assessment

In 2014, the Southwest Area Transmission group (SWAT) conducted a study (Southwest Area Transmission 2014) with the following initial objectives:

- To identify possible reliability issues due to loss of inertia and/or dynamic reactive capability associated with anticipated coal plant shutdowns.
- To identify potential limit to shutdowns through sensitivity analysis.

A baseline case and four additional cases were created to represent potential coal reduction (CR) scenarios as follows:

- Baseline Case: no coal reduction
- Expected CR Scenario with Planned Natural Gas (NG)
- Expected CR with RE replacement
- High CR, High RE
- High CR with High RE and Planned NG

The cases were analyzed to assess impacts to transient stability. Of these four cases, three were found to be stable. Only the High CR, High RE case was found to have voltage stability issues. However, no potential mitigation steps were investigated.

2. WECC 111(d) Phase 1

In response to the EPA's proposed CCP rule, WECC performed a preliminary analysis of the possible impacts to the western U.S. interconnection. In particular, this analysis focused on the "potential impacts that resource mix changes, such as coal

resource displacement and/or retirements, could have on regional and West-wide planning reserve margins or other reliability criteria..." (WECC 2014, 3). One of several criteria evaluated by WECC was frequency response. This investigation involved a base case and two Clean Power Plan scenarios:

- 3,000 MW of coal replaced with inverter-based generation (RE).
- 7,000 MW of coal replaced by inverter-based generation (RE).

According to WECC's analysis, "the 'worst case' scenario, where 7,000 MW of coal generation was replaced with an inverter-based model, did not significantly change the system frequency response for the specific condition studied (heavy summer)." Similar results were observed in the TEPPC case where 3,000 MW of generation was replaced. The study results suggest that removing the specified amount of coal generation, given the assumptions, would have minimal impact on system frequency response. The minimal change in frequency response is not surprising given that 7,000 MW of incremental retirements represents only about 3.5 percent of the total generation (198,000 MW) in the "heavy summer case" (WECC 2014, 23).

3. WWSIS Phase 3

The Western Wind and Solar Integration Study Phase 3 (WWSIS-3) (Miller et al. 2014), published by the National Renewable Energy Lab (NREL), evaluated two specific aspects of fundamental frequency system stability, frequency response and transient stability, under a high penetration of RE across the western U.S.

Of particular relevance to the Arizona build-out study are the results pertaining to utility-scale PV. WWSIS-3 investigated a scenario whereby governor controls were installed on all new utility-scale PV, which provided frequency response capabilities via curtailment of about five percent of solar PV resources (about 820 MW out of 16 GW). This measure provided significantly better frequency response compared to "business-as-usual." In fact, for Arizona in particular, frequency response improved from 69 MW/0.1 Hz under the base case to 237 MW/0.1 Hz under the high RE scenario.

Role of Arizona Policy-Makers

In consideration of the grid reliability issues discussed herein, the Arizona RE build-out scenario appears feasible if appropriate steps are taken in terms of system planning and engineering analysis. In fact, proper design of RE plants can provide certain benefits to grid reliability. SWAT, WECC, and NREL studies all identified scenarios whereby large amounts of renewable generation (in conjunction with coal retirement) do not significantly threaten grid reliability. However, there are many questions that Arizona policy-makers may want to consider:

- Are there any locations where reactive power will be needed under the CPP?

  For instance, what might those needs be if the majority of Arizona's coal resources, which presumably are a potential source of reactive power and are in the eastern part of the state, are curtailed or retired?

- Do the locations of reactive power needs overlap with the RE build-out?
- Can RE resources in the build-out areas be used to supply reactive power?
- Do the transient stability concerns identified by SWAT persist under any of the following conditions?

  Alternative RE locations

  Alternative RE provision of voltage control and reactive power

- Do the Maximum Load Serving Capability concerns identified by APS[16] persist under different mixes and locations of wind and solar?

Recommendations for Facilitating the Renewable Energy Build-out

There is great potential for Arizona to develop more renewable energy to meet its obligations under the Clean Power Plan provided federal and state decision-makers, utilities, developers, and other stakeholders take specific steps to facilitate this process and ensure that compliance will be cost-effective and timely.

Promote siting opportunities on U.S. Bureau of Land Management (BLM) lands for large-scale renewable projects that may assist the state in meeting its carbon-reduction goals under the Clean Power Plan rule.

The BLM has conducted two environmental assessments (Western Solar Plan and Restoration Design Energy Project) that screened and designated 8,256 acres as Solar Energy Zones (SEZs) and 192,100 acres as Renewable Energy Development Areas (REDAs) as potentially suitable for renewable energy development. This study's build-out scenario assumed development in the three SEZs and a subset of REDAs, the latter selected for their size and proximity to existing solar projects and existing or planned transmission lines. In support of the Clean Power Plan rule, the BLM should issue a "Notice Seeking Public Interest for Solar Development" in Arizona subsequent to EPA's release of the plan's final rule, soliciting preliminary letters of interest for renewable energy projects on both SEZs and REDAs. Should there be demonstrated interest, the BLM should then schedule a competitive auction to select high bidders and preferred applicants to submit right-of-way applications for solar energy projects within SEZs and REDAs.

Work collaboratively to further evaluate the viability of SEZs and REDAs for renewable energy development.

While the BLM has done a considerable job in assessing SEZs and REDAs as potentially suitable for renewable energy development, these areas could benefit from additional "due diligence" both from an environmental and development standpoint. New data, such as updated Federal Emergency Management Agency floodplain designations, could be used to screen areas for potential constraints. Additionally, analyses regarding where and how generation would tie into existing or planned transmission could help determine the feasibility of development within these areas. However, such due diligence needs to be targeted, as agencies' and stakeholders' resources are limited. Utilities and developers should take a proactive approach to identifying areas that they believe may be potentially suitable for multiple projects then working with agencies and stakeholders to further evaluate these areas.

Create an inter-agency task force to coordinate and expedite environmental reviews of proposed large-scale renewable energy generation projects in response to the Clean Power Plan rule.

New large-scale renewable energy projects that respond to the rule's goals and timelines will likely require reviews at the federal, state, and local levels. Greater collaboration among permitting agencies could help ensure that well-sited projects are built in a timely fashion. The Secretary of Interior and Governor of Arizona should appoint a task force, jointly chaired by a lead federal and state agency, to collect and share project-specific information, and coordinate federal- and state-level project review schedules. Participating agencies should include, but not be limited to, U.S. Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Department of Energy, Arizona Corporation Commission, Arizona Department of Environmental Quality, Arizona State Land Department, and Arizona Game and Fish Department.

Facilitate large-scale renewable energy development in response to the Clean Power Plan rule by extending development incentives accorded to the BLM's SEZs to REDAs.

As part of its Western Solar Plan, the BLM is seeking to incentivize solar development in 17 SEZs in six southwestern states including Arizona. In addition to expediting environmental review for projects located in these zones, the BLM is providing leasing incentives and establishing regional mitigation programs for projects located in SEZs. The BLM should extend these incentives to projects located in REDAs, since these areas have undergone comparable environmental reviews and share policy goals to encourage solar development in low-conflict areas. Specifically:

1. Project applications within REDAs should be ranked higher priority for processing than other projects located on Variance Lands identified in the Western Solar Plan.

2. REDAs should be considered as Designated Leasing Areas under the BLM's Competitive Leasing Rule for Wind and Solar, and receive the same level of incentives as SEZs under the rule.

3. Regional mitigation programs developed for Solar Energy Zones should apply to projects within Renewable Energy Development Areas that have similar resources and values and that are located in the same Resource Management Plans as the zones.

Fully fund the first regional periodic review of West-wide Energy Corridors (Section 368), covering western Arizona, southern Nevada, and the California desert.

Required as a result of a legal settlement, this review would extend across a region where enhanced transmission capacity could provide renewable energy access to both in- and out-of-state markets in response to the rule (particularly for Arizona solar and New Mexico wind). Such a review would provide an environmental screening of currently designated and new potential transmission corridors, addressing impacts on wildlife, habitat, view sheds, and cultural and historic resources. It would extend to federal and non-federal lands, though actual corridor designations would be limited to federal lands. Based on consultations with state officials, utilities, energy and transmission developers, and other stakeholders, this review could ensure that corridors align with renewable energy generation and transmission development needs triggered by the Clean Power Plan rule. Congress should approve the BLM's $5 million requested increase in their budget under the new Cadastral, Lands, and Realty Management sub-activity to carry out regional periodic reviews.

Advocate for the consideration of detailed renewable energy build-out scenarios in regional transmission planning.

There are a number regional transmission planning efforts led by—among others—the Western Electricity Coordinating Council, WestConnect, and the Southwest Area Transmission sub-regional planning group that will be considering future energy deployment scenarios. FERC Order 1000 requires that these transmission planning efforts be responsive to federal and state policies, like the Clean Power Plan. These efforts should consider detailed renewable energy build-out scenarios like the one provided in this study. Taking this step will further integrate planning around renewable energy generation and transmission, which has been lacking to date. Build-out scenarios also will help pinpoint where reliability issues may arise as a result of increased renewable energy development and identify the need for additional ancillary services and other mitigation actions. Environmental groups, renewable energy advocates, and other stakeholders should collaborate in submitting formal requests to study these scenarios as part of regional transmission planning initiatives.

Evaluate a renewable energy build-out scenario similar to this project as a component of the Arizona Corporation Commission's biennial energy assessment.

Additionally, the Arizona Corporation Commission biennially reviews the 10-year plans of utilities, public agencies, and private developers intending to build transmission and issues a statement regarding the adequacy of Arizona's existing and future transmission system. The commission occasionally makes special requests as part of the biennial assessment, such as asking builders to identify proposed transmission lines that will facilitate getting renewable energy to markets. The commission should consider requesting that a build-out renewable energy scenario like the one provided in this study be evaluated as part of the next biennial assessment.

Evaluate detailed renewable energy build-out scenarios as part of utilities' integrated resource planning processes.

The current integrated resource planning process undertaken by the Arizona Corporation Commission has been successful in providing a wealth of information to stakeholders. However, there are some pieces of information that are still missing. For instance, while utilities provide information on the quantity of future renewable energy resources under consideration, there is less known about specific locations under consideration. We recommend that utilities and the ACC strive to have future integrated resource planning efforts provide better information about the locational requirements or preferences of their renewable resource portfolios over time.

Assess policies or other actions that would compensate utilities and developers for providing ancillary services along with renewable energy generation.

Investigate payment for ancillary services: The full value of providing ancillary services from renewable resources in Arizona is not widely known. As the build-out occurs, there may be an opportunity to capture this value that would be more difficult to do once projects are built and operational. We suggest that utilities, transmission planners, developers, and regulators proactively coordinate to investigate the specific need for ancillary services and what incentive structures would be necessary to ensure delivery of these services. The time necessary to complete these studies, and the cost of any system impact mitigation measures required could present additional barriers to the development of large-scale RE projects. Project developers, utilities, and their regulators should work together to ensure that these studies successfully minimize mitigation costs by considering the full range of possible project configurations and capabilities.

Appendix A

Build-out Study Advisory Group

Name	Organization
Erik Bakken	Tucson Electric Power
Ron Belval	Tucson Electric Power
Michele Boyd	Abengoa Solar
Lisa Briggs	Sempra U.S. Gas & Power
Eddie Burgess	Arizona State University's Energy Policy Innovation Council
Ian Calkins	Copper State Consulting Group
Eliza Cava	Defenders of Wildlife
Lane Cowger	Arizona Bureau of Land Management
Tom Darin	American Wind Energy Association
Alex Daue	The Wilderness Society
Ian Dowdy	Sonoran Institute
Jason Du Terroil	Iberdrola Renewables
Cameron Ellis	Sonoran Institute
Katherine Gensler	Solar Energy Industries Association
Jason Howard	Maricopa Association of Governments
Erin Lieberman	Defenders of Wildlife
Alex Martin	First Solar, Inc
Kris Mayes	Sandra Day O'Connor College of Law, Arizona State University
Mahesh Morjaria	First Solar, Inc
Fred Morse	Abengoa Solar
Amanda Ormond	The Ormond Group
Rob Peters	Defenders of Wildlife
Marcos Robles	The Nature Conservancy
Grant Rosenblum	NextEra Energy Resources
Erni Rubi	Town of Gila Bend
Richard Rushforth	Walton Sustainability Solutions Initiatives, Arizona State University
Ravi Sankaran	SunEdison
Jessica Scott	Vote Solar
Kevin Seegmiller	School of Sustainability, Ph.D. Student, Arizona State University
John Shepard	Sonoran Institute
Parikhit Sinha	First Solar, Inc
Kari Smith	SunPower
Katherine Stainken	Energeia
Brandon Stankiewicz	NextEra Energy Resources
Richard Stuhan	Arizona Public Service
Dale Turner	The Nature Conservancy
Andrew Wang	Solar Reserve
Maja Wessels	First Solar, Inc
Kevin Yates	SunEdison

Appendix B1

Detailed List of Renewable Energy Projects (Continued on following page)

Project Name	Owner	Capacity (MW)	Generation (MW/hrs)	CO2 Displaced (Tons)	Project Status
Aztec	Solar Reserve	13.5	30,500	16,900	The Aztec Solar Project is being developed by SolarReserve. This 13.5 MW solar photovoltaic project is located on private land in Yuma County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. The project currently does not have a power purchase agreement.
AVSE I	Arlington Valley Solar Energy	125	286,300	155,000	The AVSE I Project is being developed Arlington Solar Valley. This 125 MW solar photovoltaic projects is located on private land in Maricopa County. This project required no federal environmental review. It received a Certificate of Environmental Compatability from the Arizona Corporation Commission in 2010. The county approved a comprehensive plan amendment in 2010 and special use permit in 2011. AVSE I is part of a two-part project. AVSE II was built and operating by 2013 and has a power purchase agreement with San Diego Gas and Electric. AVSE I does not have a power purchase agreement.
Cotton Center 3 & 4	Solar Reserve	40	90,600	50,200	The Cotton Center 3 & 4 Solar Project is being developed by SolarReserve. This 40 MW solar photovoltaic project is located on private land within the Town of Gila Bend in Maricopa County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. The town approved zoning changes and a site plan for the project in 2011. The project currently does not have a power purchase agreement.
Crossroads Solar	Solar Reserve	150	339,700	188,700	The Crossroads Solar Project is being developed by SolarReserve. This 150 MW concentrated solar project is located on private land in Maricopa County. It will employ a central receiver ("power tower") technology with wet-cooling , providing 10 hours of storage capacity. This project required no federal environmental review. It received a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee in 2011. The county approved a comprehensive plan amendment and special land use permit in 2010. The project currently does not have a power purchase agreement.
Hyder	Solar Reserve	20	45,300	25,100	The Hyder Solar Project is being developed by SolarReserve. This 20 MW solar photovoltaic project is located on private land in Maricopa County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. The county approved a comprehensive plan amendment and special land use permit in 2012. The project currently does not have a power purchase agreement.
Maricopa Solar Park	Marisol Energy	300	679,800	378,400	The Maricopa Solar Park Project is being developed by Marisol Energy. This 300 MW solar photovoltaic project is located on BLM land in Maricopa County. The project initiated the federal environmental review process in 2013. The initial scoping phase was completed before the review process was suspended in 2014 at the developer's request while a power purchase agreement is pursued. The project will require the issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee, as well as county approval of a land-use amendment, rezoning, and building permits.
Mesa Solar	First Solar	50	113,200	62,700	The Mesa Solar Project is being developed by First Solar. This 50 MW solar photovoltaic project is located on state trust land in Pinal County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. This project did secure a comprehensive land-use amendment and rezoning from the county in 2014. It still requires approval from the State Land Department. The project currently does not have a power purchase agreement.
Mini Mesa Solar	First Solar	20	45,300	25,100	The Mesa Solar Project is being developed by First Solar. This 20 MW solar photovoltaic project is located on state trust land in Pinal County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. This project did secure a comprehensive land-use amendment and rezoning from the county in 2014. It still requires approval from the State Land Department. The project currently does not have a power purchase agreement.

Detailed List of Renewable Energy Projects Part 2

Project Name	Owner	Capacity (MW)	Generation (MW/hrs)	CO2 Displaced (Tons)	Project Status
Mohave Wind	Orion	500	1,078,300	604,200	The Mohave County Wind Project was originally proposed by Orion Energy Group before being sold to BP Wind Energy and then reacquired by Orion in 2015. This 500 MW wind project is located on Bureau of Land Management Land and Bureau of Reclamation lands in Mohave County. The project successfully completed its federal environmental review in 2013. It has not yet applied for a Certificate of Environmental Compatibility from Arizona Corporation Commission's Line Siting Committee. The project is currently having study work performed by Western Area Power Administration but does not yet have an active interconnection agreement. Orion has been in consultation with Mohave County to determine which permits and environmental plans will be required prior to the start of construction. The project currently does not have a power purchase agreement.
Octavia Greenworks	Sunpower	195	441,700	245,600	The Octavia Greenworks Project is being developed by Sunpower. This 195 MW solar photovoltaic project is located on private land within the Town of Gila Bend in Maricopa County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. The project currently does not have a power purchase agreement.
Pima Road	Iberdrola Renewables	48	109,800	59,300	The Pima Road Project is being developed by Iberdrola Renewables. This 48MW photovoltaic project is located on state trust land in Pinal County. Biological,Section 404 evaluations and a Phase I ESA have been performed on the site. A land-use planning amendment was completed in 2011 but a zoning change approval is still required by the County as well as building permits. The project does not have a PPA and a signed interconnection agreement is expected in the 2nd quarter of 2016.
Quartzite Solar	Solar Reserve	100	226,400	125,600	The Quartzite Solar Project is being developed by SolarReserve. This 100 MW concentrated solar project is located on Bureau of Land Management Land in La Paz County. It will employ a central receiver ("power tower") technology with dry cooling, providing # hours of storage capacity. The project successfully completed its federal environmental review in 2013 and was issued a right-of-way grant in 2014. It has not yet applied for a Certificate of Environmental Compatibility from Arizona Corporation Commission's Line Siting Committee. The project does have an active interconnection studyagreement with the Western Area Power Administration. The project currently does not have a power purchase agreement.
Rainbows	Solar Reserve	20	45,300	25,100	The Rainbows Solar Project is being developed by SolarReserve. This 20 MW solar photovoltaic project is located on private land in Cochise County. This project required no federal environmental review or issuance of a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee. The project currently does not have a power purchase agreement.
Sonoran Solar	NextEra	300	679,800	378,400	The Sonoran Solar Project is being developed by NextEra Energy Resources, LLC ("NextEra"). This 300 MW solar photovoltaic project is located on Bureau of Land Management lands in Maricopa County. The project successfully completed its federal environmental review in 2011 and was issued a right-of-way grant 2012. It received a Certificate of Environmental Compatibility from Arizona Corporation Commission's Line Siting Committee in 2012. The project currently does not have a power purchase agreement. NextEra is currently completing a revised interconnection study prior to entering into a Large Generator Interconnection Agreement to facilitate connection to the Jojoba Substation. It is anticipated, based on prior assessments, that upgrades necessary for the interconnection will be limited to those within the footprint of the substation. Building permits and other ancillary approvals from Maricopa County and the Town of Buckeye would be required prior to starting construction.
Sun Streams Solar	First Solar	150	339,700	188,700	The Sun Streams Solar Project is being developed by First Solar. This 150 MW solar photovoltaic project is located on private land in Maricopa County. This project required no federal environmental review. It received a Certificate of Environmental Compatibility from the Arizona Corporation Commission's Line Siting Committee for its Gen-tie line in 2014. It still requires county land-use plan amendments, rezoning, and building permits prior to starting construction. The project currently does not have a power purchase agreement.
Totals		2,032	4,551,700	2,529,000	

Appendix B2

Detailed List of Renewable Energy Build-Out Areas (Continued on following page)

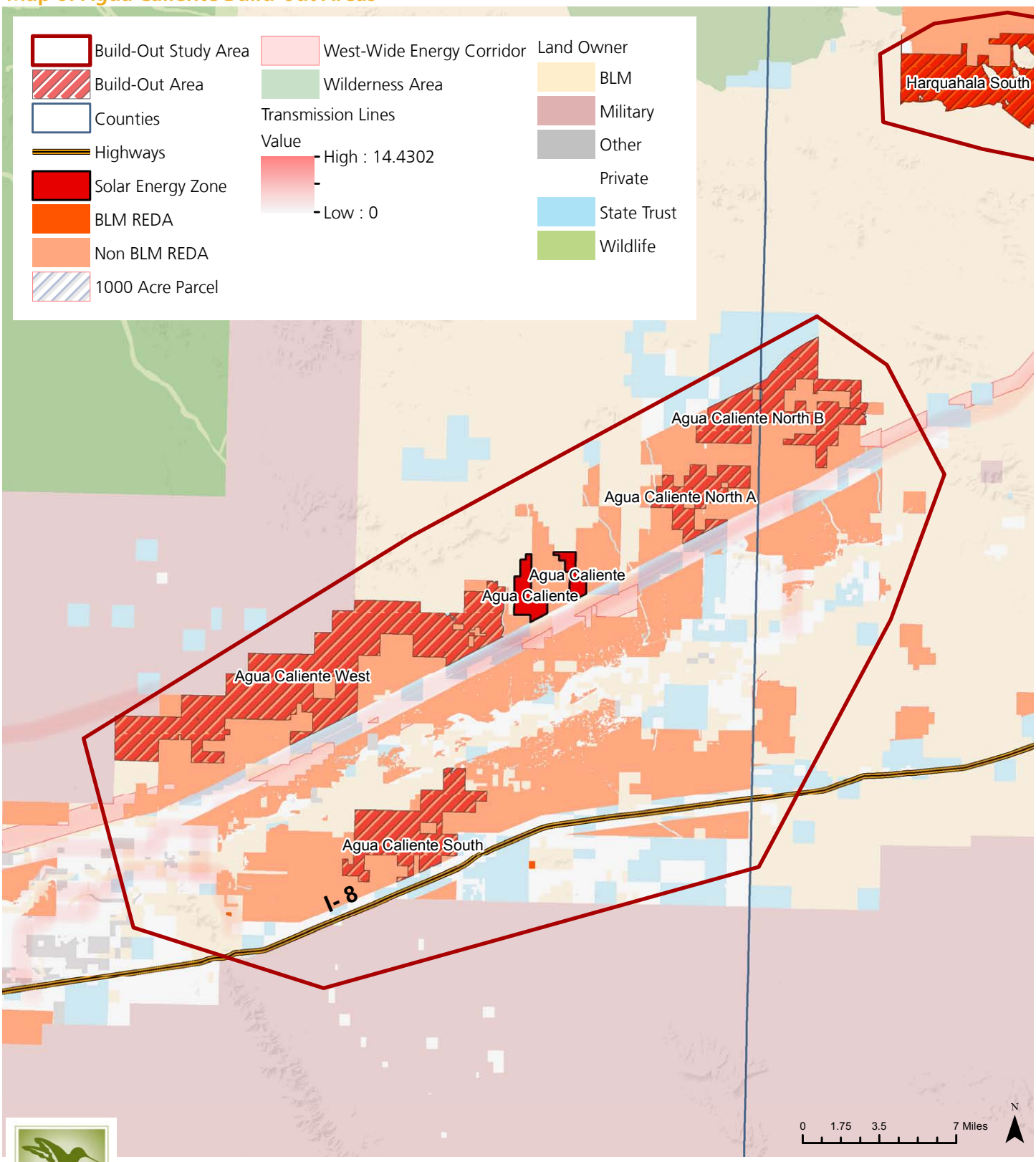
Build-Out Study Area	Parcel Name	Land Ownership	Total Acres	Total Capacity (MW)	Developable Acres	Capacity, Developable Acres (MW)	Build-out Scenario Acres
Agua Caliente	Agua Caliente SEZ	BLM	2,560	366	2,021	289	-
	South	State Trust	9,070	1,296	6,803	972	6,803
	West	State Trust	27,965	3,995	20,974	2,996	20,974
	North A	State Trust	4,565	652	3,424	489	-
	North B	State Trust	10,693	1,528	8,020	1,146	8,020
Rainbow Valley	West	BLM	1,031	147	567	81	-
	Central	BLM	2,248	321	1,236	177	1,236
	East	BLM	6,043	863	3,324	475	3,324
Palo Verde	Gillespie Dam SEZ	BLM	2,618	374	2,231	319	2,231
	Southeast	BLM	1,784	255	981	140	-
Harquahala South	Harq. South	BLM	16,087	2,298	8,848	1,264	8,848
Harquahala North	West	BLM	3,353	479	1,844	263	-
	Central	BLM	3,464	495	1,905	272	1,905
Renegras	Brenda SEZ	BLM	3,348	478	1,906	272	-
	Ranegras Central A	BLM	2,023	289	1,113	159	1,113
	Ranegras Central B	BLM	1,181	169	650	93	-
	Ranegras North A	BLM	1,038	148	571	82	-
	Ranegras North B	BLM	4,882	697	2,685	384	2,685
	Ranegras North C	BLM	1,059	151	582	83	-
	Ranegras South	BLM	1,736	248	955	136	-
	Ranegras West	BLM	4,712	673	2,592	370	2,592
Salome	East	BLM	1,216	174	669	96	-
	West	BLM	4,853	693	2,669	381	2,669
Mohave	North	BLM	2,248	321	1,236	177	1,236
	South	BLM	1,367	195	752	107	-
	Totals		**121,144**	**17,306**	**78,557**	**11,222**	**63,636**

Detailed List of Renewable Energy Build-Out Areas Part 2

Build-Out Study Area	Parcel Name	Capacity, Build-out Scenario (MW)	Build-out Scenario, Generation (MWh)	Build-out Scenario, CO2 Displaced (Tons)	Notes
Agua Caliente	Agua Cal. SEZ				Non-Developable Area (NDA) de-termined by BLM.
	South	100	228,900	123,800	NDA=25%
	West	300	687,300	374,600	NDA=25%
	North A	-	-	-	NDA=25%
	North B	200	458,300	248,900	NDA=25%
Rainbow Valley	West	-	-	-	NDA=45%
	Central	70	160,100	86,500	NDA=45%
	East	150	343,700	186,300	NDA=45%
Palo Verde	Gillespie Dam SEZ	120	274,800	148,800	NDA determined by BLM.
	Southeast	-			
Harquahala South	Harq. South	300	687,300	374,600	NDA=45%
Harquahala North	West	-			NDA=45%
	Central	250	572,800	311,700	NDA=45%
Renegras	Brenda SEZ	-			NDA determined by BLM.
	Ranegras Central A	100	228,900	123,800	NDA=45%
	Ranegras Central B	-	-	-	NDA=45%
	Ranegras North A	-	-	-	NDA=45%
	Ranegras North B	300	687,300	374,600	NDA=45%
	Ranegras North C	-	-	-	NDA=45%
	Ranegras South	-	-	-	NDA=45%
	Ranegras West	200	458,300	248,900	NDA=45%
Salome	East	-	-	-	NDA=45%
	West	90	205,900	111,300	NDA=45%
Mohave	North	100	228,900	123,800	NDA=45%
	South				NDA=45%
	Totals	**2,280**	**5,222,500**	**2,837,600**	

Appendix C

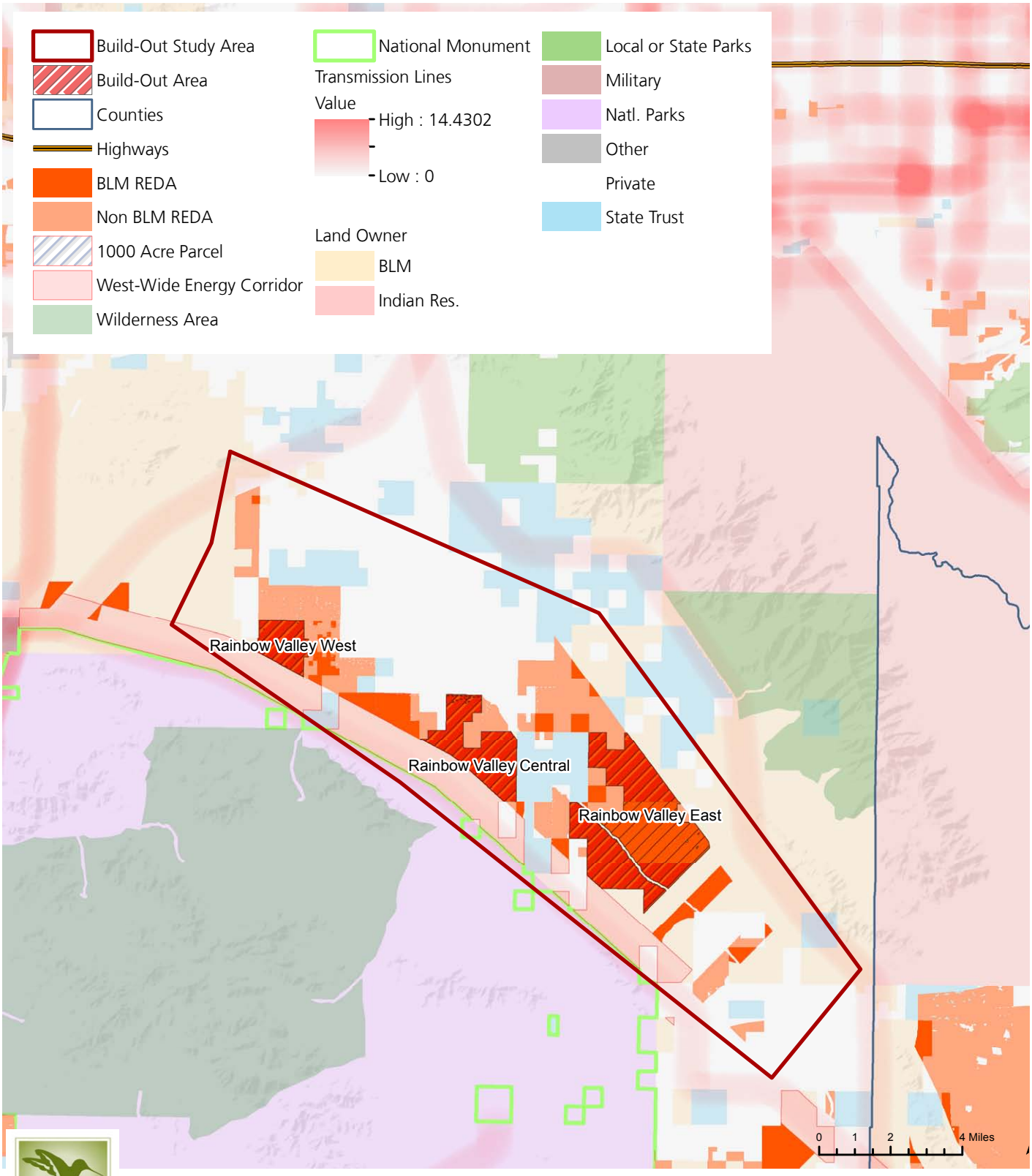
Map of Agua Caliente Build-out Areas



Build-Out Areas

Appendix D

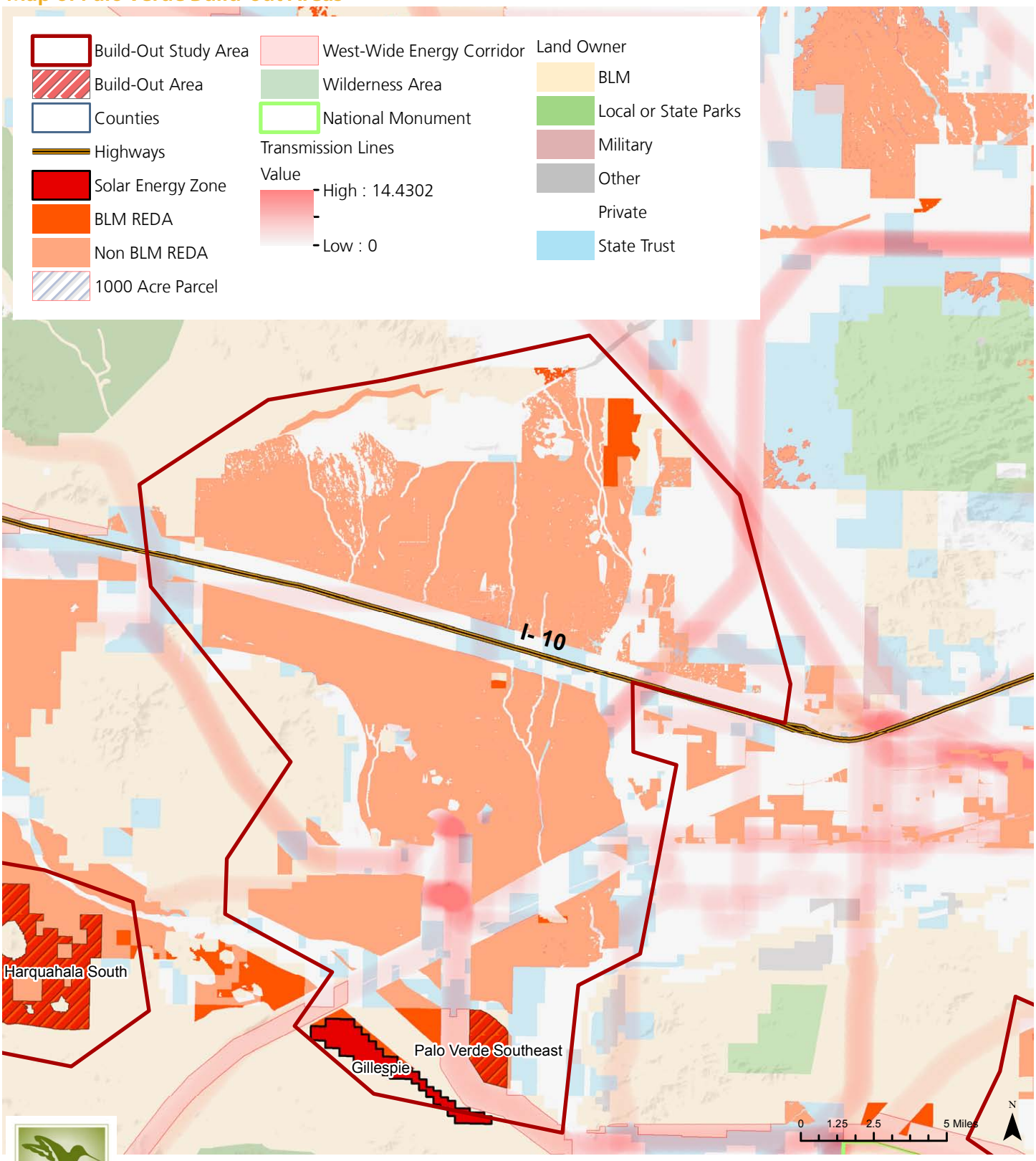
Map of Rainbow Valley Build-out Areas



Build-Out Areas

Appendix E

Map of Palo Verde Build-out Areas

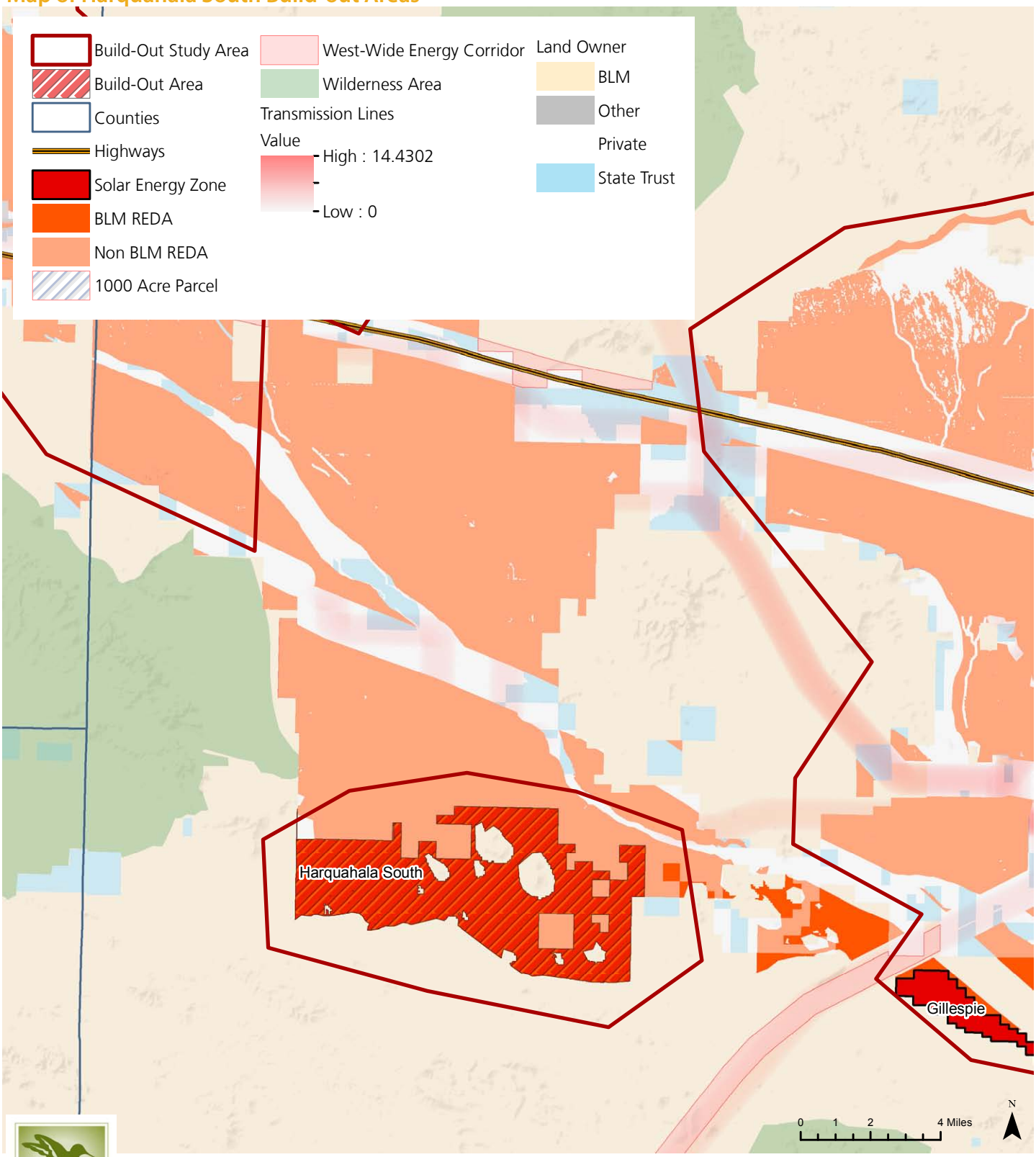


SONORAN INSTITUTE

Build-Out Areas

Appendix F

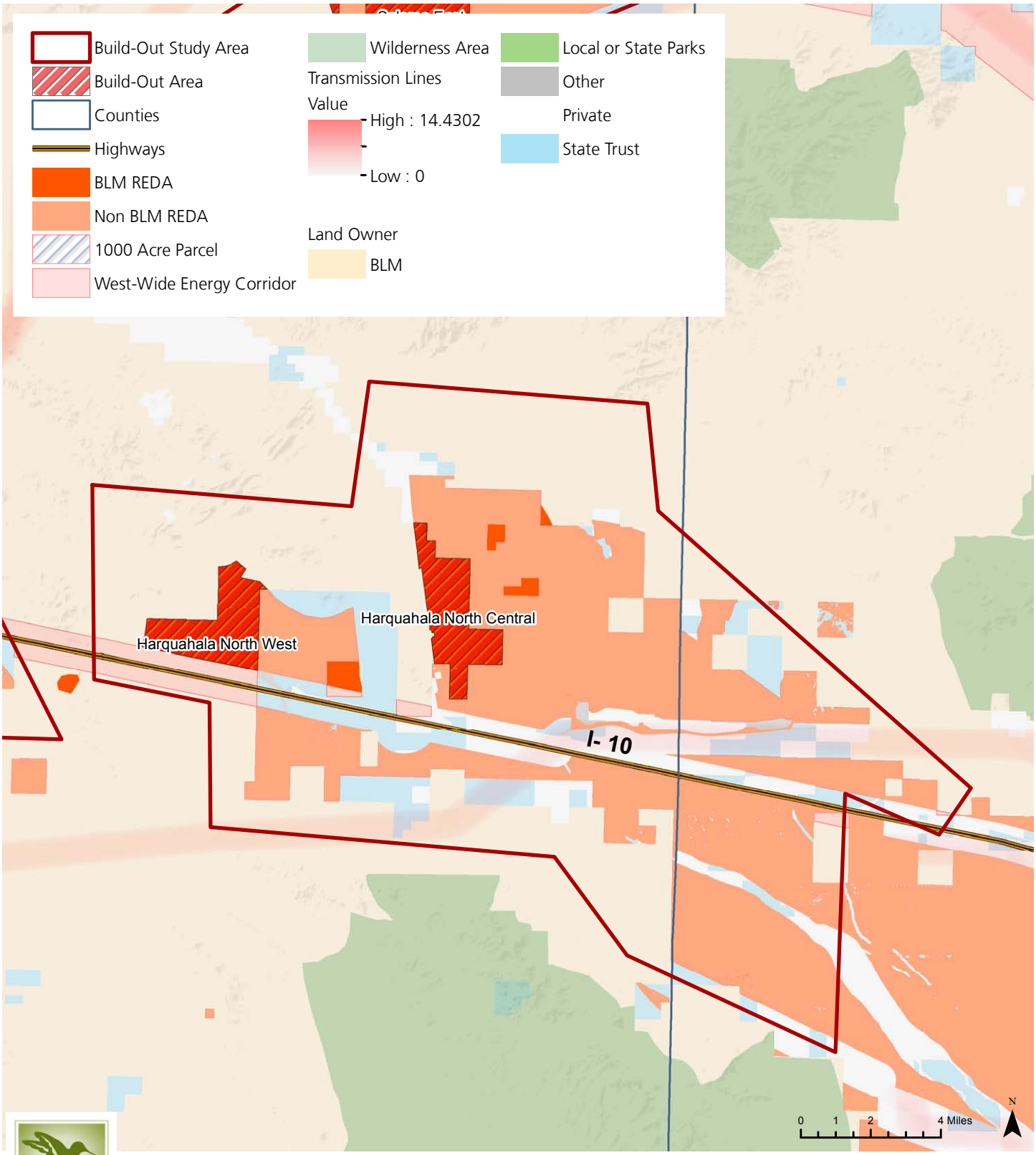
Map of Harquahala South Build-out Areas



Build-Out Areas

Appendix G

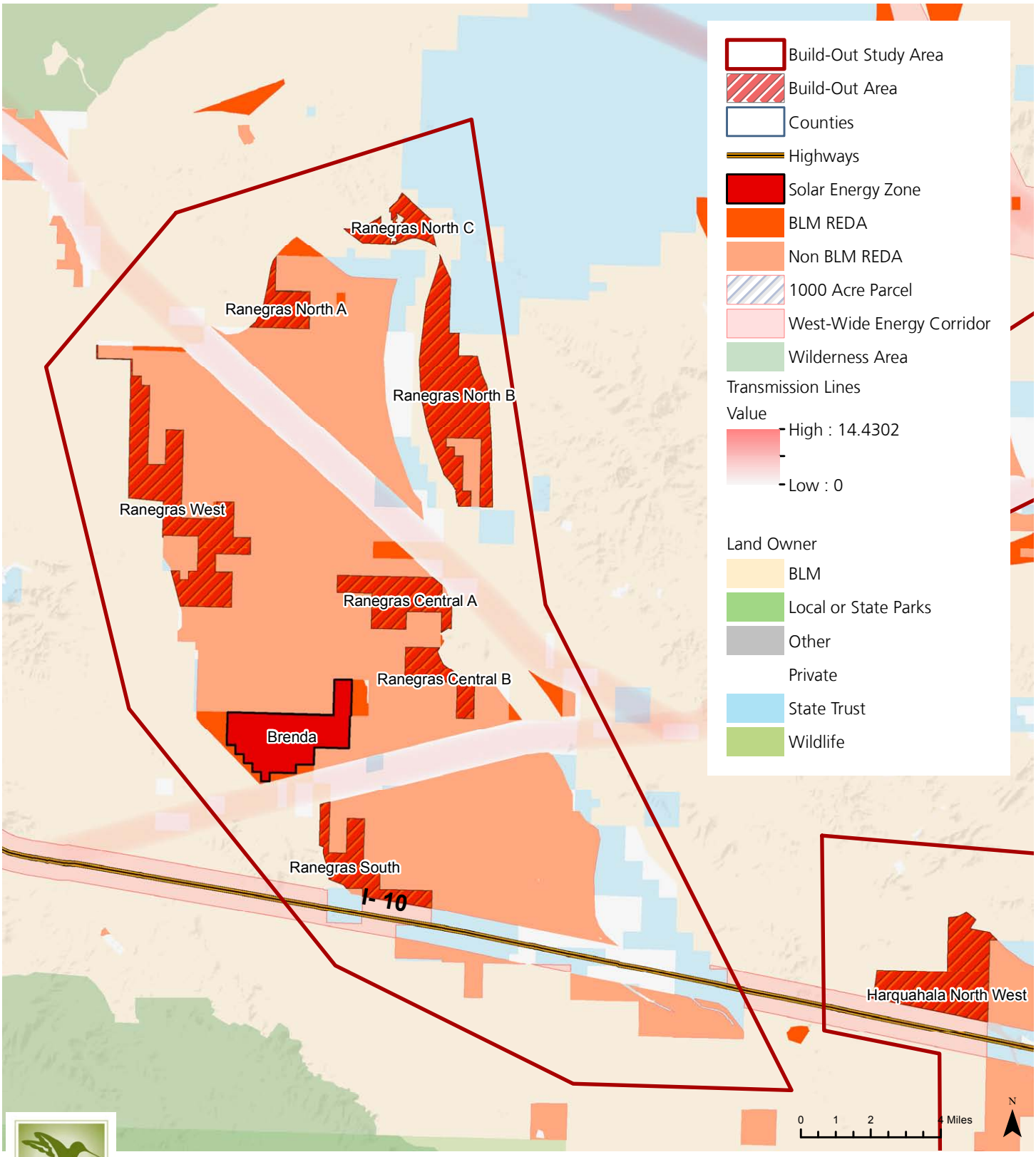
Map of Harquahala North Build-out Areas



Build-Out Areas

Appendix H

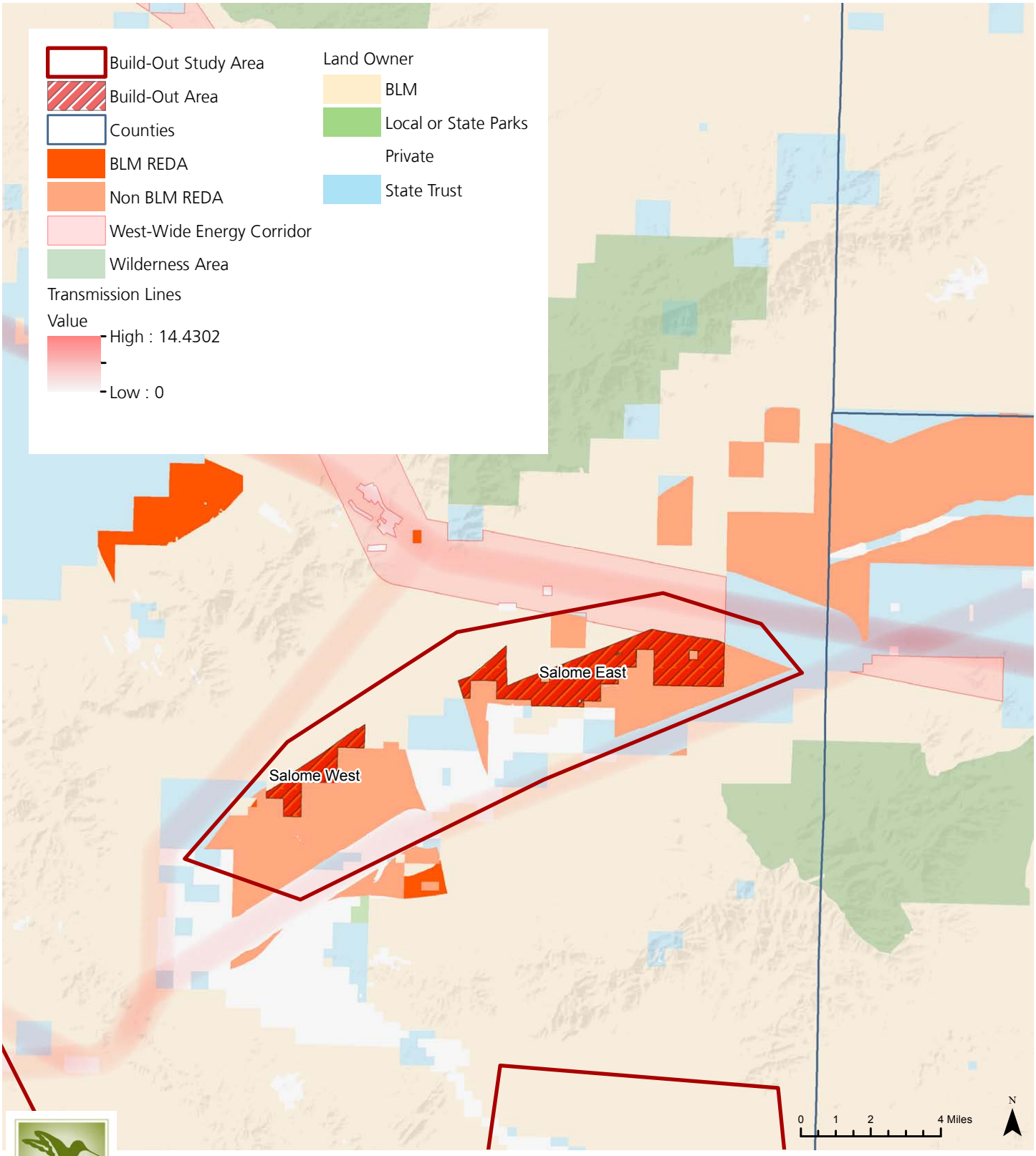
Map of Renegras Plain Build-out Areas



Build-Out Areas

Appendix I

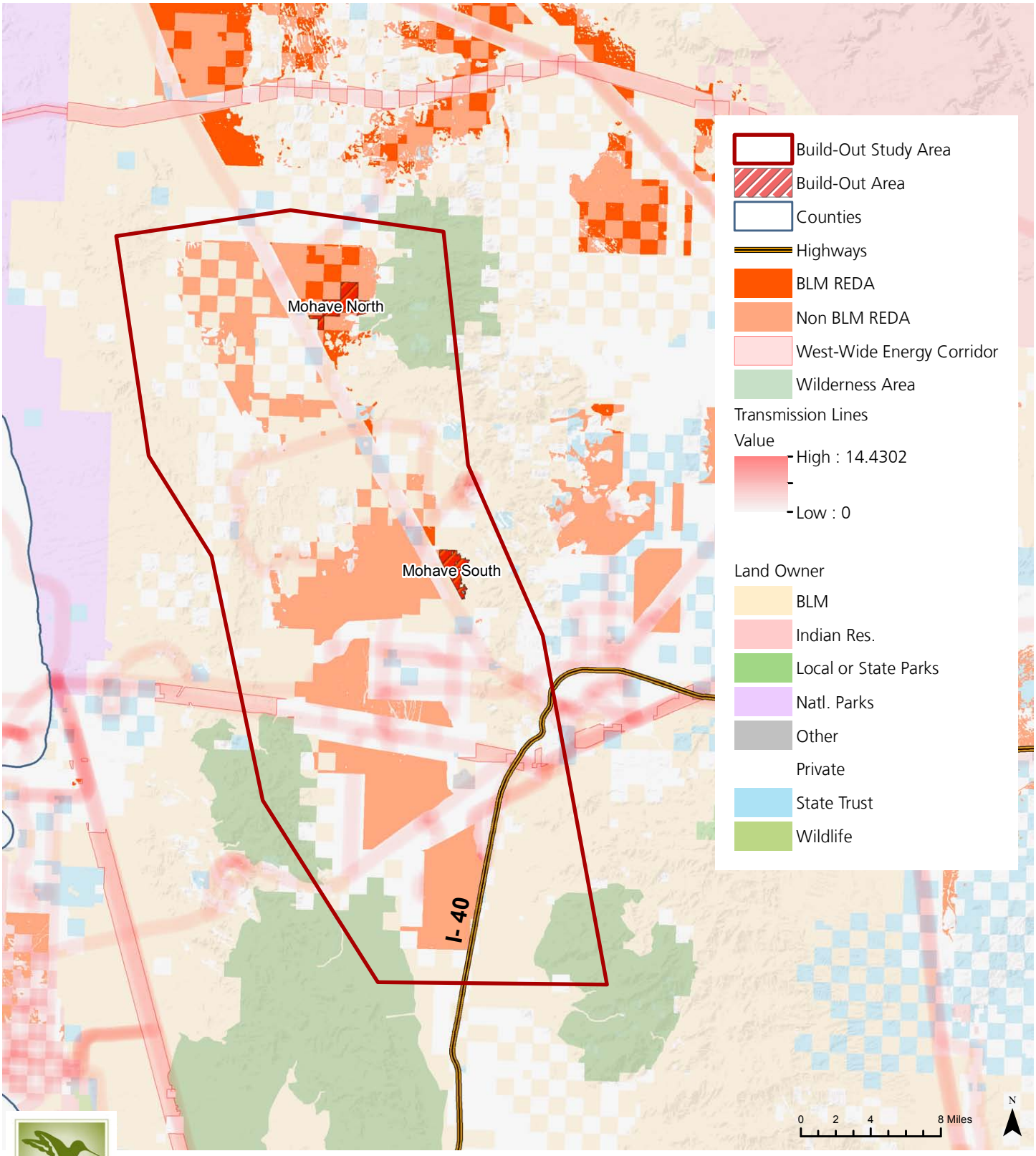
Map of Salome Build-out Areas



Build-Out Areas

Appendix J

Map of Mohave Build-out Areas



Build-Out Areas

Appendix K

Transmission Owners' Interconnection Queue

Transmission Owner	Location (County)	Type	Capacity (Max Output) in MW	Studies Completed	Projected In-Service Date
APS	Coconino	Wind	1000	SIS, FAS	Oct 2017
APS	Maricopa	Solar PV	20	SIS, FAS	June 2017
APS	Coconino	Wind, Solar PV	101, 60	SIS, FAS	Sept 2017
APS	Maricopa	Solar PV	200	--	Dec 2018
SRP	Pinal	Solar PV	20	FAS	May 2016
SRP	Pinal	Solar PV	51	FAS	May 2016
SRP	Pinal	Solar PV	50	--	Oct 2016
SRP	Pinal	Solar PV	125	--	May 2014
SRP	Pinal	Solar PV	50	--	Aug 2016
SRP	Maricopa	Solar PV	125	SIS, FAS	Jan 2016
SRP	Maricopa	Solar PV	200	SIS, FAS	May 2013
SRP	Maricopa	Solar PV	150	SIS, FAS	Dec 2016
SRP	Maricopa	Solar PV	300	--	Dec 2018
WAPA	Mohave	Wind	425	?	Oct 2009
WAPA	La Paz	Solar Thermal	110	?	July 2013
WAPA	La Paz	Solar Thermal	150	?	Sept 2015
WAPA	Mohave	Solar PV	45	?	Jan 2016
WAPA	Maricopa	Solar PV	100	?	Jan 2016
WAPA	Mohave	Solar PV	300	?	June 2017
UNSE	Mohave	Solar PV(?)	70	--	July 2016
Total			**3,652**		

Endnotes

1 Or a 32% reduction compared to 2005, the baseline the U.S. is using for its international climate pledges.

2 The EPA used actual 2012 figures as their starting reference point.

3 California, Nevada, and New Mexico are the other three.

4 This assessment, Restoration Design Energy Project, was completed by the Arizona Office of the U.S. Bureau of Land Management in 2013. Information about this assessment can be found at: http://www.blm.gov/az/st/en/prog/energy/arra_solar.html.

5 The Palo Verde Hub—including the 3,875 MW Palo Verde Nuclear Generating Station, the largest power plant in the country, and neighboring natural gas and solar plants—totals approximately 10,000 MW of generating capacity.

6 Adopted in 2006, Arizona's Renewable Energy Standard and Tariff requires that 5% of electricity generated in the state must come from qualifying renewables by 2015, 10% by 2020, and 15% by 2025.

7 Displaced carbon emissions from implementation of the build-out scenario were estimated using the EPA AVoided Emissions and geneRation Tool (AVERT), a statistically based model for estimating displaced generation and carbon emissions from large (>25 MW) fossil electrical generation units. AVERT is designed to estimate emissions displacement from energy efficiency and renewable energy programs using a statistical-driven simulation of future emissions based upon historic public data reported to EPA. The AVERT model utilizes regional data files to allow for estimations at the county-level. Arizona, with the exception of the northeast corner, is located in the Southwest region, which also includes parts of California, Nevada, New Mexico and El Paso, Texas. The projects were run in the AVERT emissions reduction and carbon displacement estimation tool. Solar projects were run as utility-scale solar projects; however, no further differentiation between PV and CSP technologies is allowed in AVERT. All information regarding the EPA AVERT tool was gathered from http://www.epa.gov/avert.

8 State trust land parcels we selected also were screened as part of RDEP and were characterized as potentially suitable for renewable energy development similar to REDAs on BLM land.

9 This is below the lowest threshold arrived at by the BLM in identifying non-developable areas in their most recent review of Arizona's three SEZs.

10 This was assumed for the sake of simplicity and uniformity in calculating generation and carbon displacement estimates. The scenario relies on NREL's 2013 study on the land-use requirement of solar power plants.

11 1000 MWh * 2000 lbs/MWh = 200,000 lbs emissions; 200,000 lbs / (1000 MWh + 533 MWh) = 1305 lbs/MWh.

12 OASIS refers to an on-line Open Access Same-time Information System for identifying and accessing available transmission line capacity in order to move wholesale quantities of electricity.

13 WestConnect is composed of utility companies providing transmission of electricity in the United States. The members work collaboratively to assess stakeholder and market needs and to develop cost-effective enhancements to the western wholesale electricity market. http://www.westconnect.com/aboutwc.php

14 WECC is the regional entity responsible for compliance monitoring and enforcement. In addition, WECC provides an environment for the development of reliability standards and the coordination of the operating and planning activities of its members. https://www.wecc.biz/Pages/About.aspx.

15 Under the self-build model, a developer would typically build the project and transfer ownership to the utility upon completion.

16 APS identified these concerns in their comments to EPA filed on December 1, 2014:

http://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OAR-2013-0602-23097&attachmentNumber=2&disposition=attachment&contentType=pdf.

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