

SURFACE COLOR TREATMENT OF TRANSMISSION LINE STRUCTURES

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Abstract.—With the increasing need for reliable energy infrastructure in the United States, the once natural openness of the Wild West has evolved into a web of infrastructure scattered across the landscape. Bureau of Land Management (BLM) lands managed under a multiple-use mission are no exception. While projects built on BLM land go through in-depth environmental analysis, including making recommendations for proper design features and mitigation measures to reduce impacts to visual resources, it is often difficult for BLM staff to ensure full implementation of these measures. This is sometimes a result of not having the expertise or tools to simulate design features and mitigation measures. This paper describes the process that the BLM followed to warrant the color treatment of built structures on a recent 500 kV transmission line through a highly scenic and publicly sensitive landscape. It highlights the process of using two-dimension (2D) visual simulations to conduct a color analysis of the natural landscape. It also demonstrates how using these techniques provided invaluable information to help BLM decision makers select the most appropriate surface color treatment for the structures in this project.

ENERGY TRANSMISSION OVERVIEW

The first long-distance electricity transmission line is believed to have been built in 1889 in Portland, Oregon; since then, thousands of miles of transmission lines have been strung across the United States (Madrigal 2010). These lines are supported by structures that vary from small roughly cut wood poles to large steel structures that are capable of withstanding the most intense abuse that nature can throw at them.

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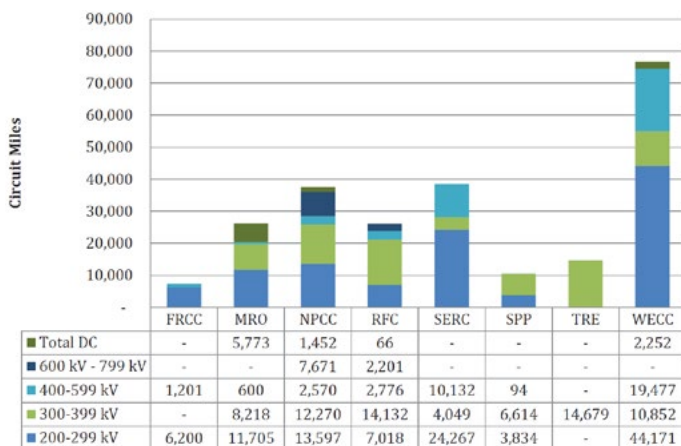


Figure 1.—Existing transmission lines as of Dec. 31, 2015 (U.S. Department of Energy 2016).

FRCC—Florida Reliability Coordinating Council. MRO—Midwest Reliability Organization. NPCC—Northeast Power Coordinating Council. RFC—ReliabilityFirst Corp. SERC—Southeast Reliability Council. SPP—Southwest Power Pool. TRE—Texas Reliability Entity. WECC—Western Electricity Coordinating Council.

As energy demand continues to increase in the United States, there is an ongoing need to expand energy transmission infrastructure. As of 2016, there were 237,871 total circuit miles of transmission lines ranging from 200 kV to 799 kV (including DC) across the United States (Fig. 1) (U.S. Department of Energy 2016). There are plans for another 14,380 circuit miles of transmission lines to be completed by 2020 (Fig. 2) and conceptual transmission projects still in early stages of development could add 2,017 more miles between 2021 and 2025 (U.S. Department of Energy 2016).

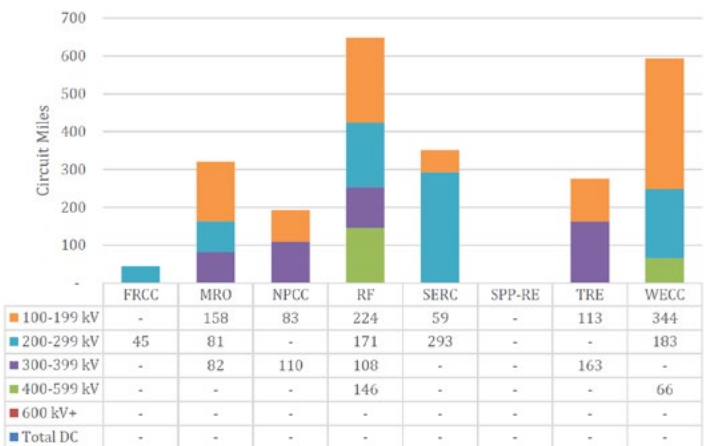


Figure 2.—New transmission lines expected to be completed by 2020 (U.S. Department of Energy 2016).

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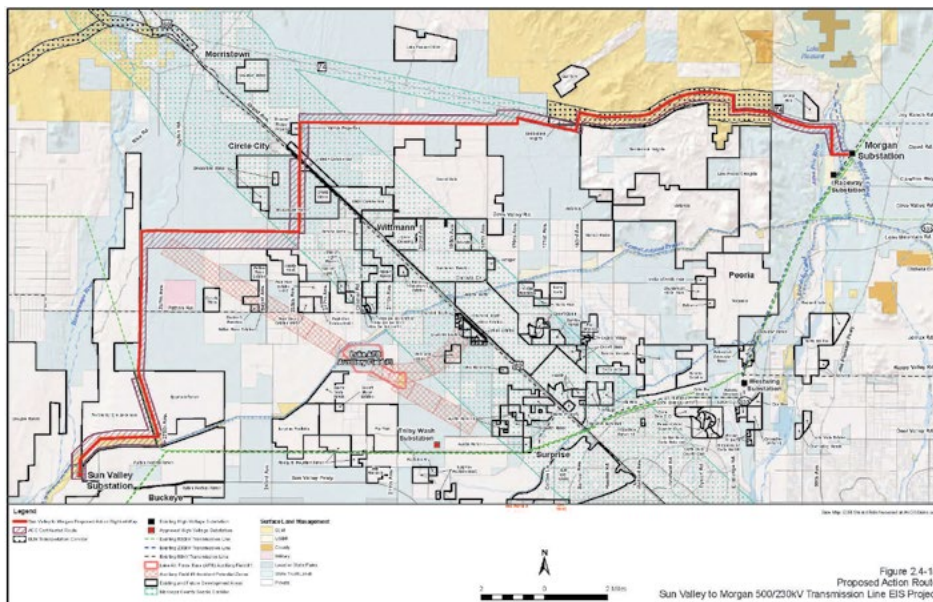


Figure 3.—Sun Valley to Morgan 500kV Transmission Line proposed action route. Source: Bureau of Land Management 2013.

As is clearly evident in these figures, reliable and efficient energy transmission, predominantly through overhead transmission lines, is a vital part of our energy dependent society.

PROJECT BACKGROUND

In the desert landscapes of Arizona, multiple electricity transmission lines are currently either under construction or in the planning stages; many of these will affect BLM lands. The Sun Valley to Morgan 500 kV Transmission Line (SV2M) is one such project. The Arizona Public Service Electric Company (APS), one of the main utility providers in Arizona, determined that they needed to build a 500 kV line to support the growing energy demand in the Phoenix-metro area. This project would provide a connection between the Sun Valley substation (north of the town of Buckeye and west of the City of Surprise) and the Morgan substation (just south of Lake Pleasant). Hence, this project is called the Sun Valley to Morgan 500 kV Transmission Line.

When the study area and proposed alignment were submitted for the project, there was significant public opposition, mainly due to proximity of the project to residential communities. This opposition led to political pressure on APS to consider a new alignment that would push the proposed SV2M route farther from the residential communities. The new proposed

alignment still connected the Sun Valley and the Morgan substations but now cut across BLM-managed public lands for approximately 7 of the 38 total miles. Specifically, the newly modified alignment followed the general area of SR74 that connects I-17 north of Phoenix to Wickenburg, Arizona (Fig. 3).

This change, while placating the groups that had opposed the SV2M original alignment, led to other challenges for APS. The BLM-managed land was not designated to allow for utility-scale energy transmission. The Bradshaw-Harquahala Resource Management Plan (RMP), the document establishing BLM planning and management objectives, did not include language that would allow such a project to be built as proposed. In fact, the RMP stated that utility-scale energy projects were required to use already designated energy corridors on BLM land (Bureau of Land Management 2010).

This area was also designated in the RMP as a BLM visual resource management (VRM) class II landscape. VRM class II lands are established to retain the existing natural condition of the landscape, allowing for some minor modification that does not attract the attention of casual observers. Due to the highly scenic quality of the proposed alignment, along with the public sensitivity to change along the scenic SR74 highway, it was unlikely that a 500 kV transmission line would conform to this objective.

Because of the conflict between the proposed action and the objectives in the RMP, a plan amendment (RMPA) would have to be processed. The BLM field office decided to proceed with the RMPA and an environmental impact statement (EIS) for the proposed action (Fig. 4).

ENVIRONMENTAL IMPACT STATEMENT ANALYSIS

The BLM study assessed both the impacts of amending the RMP to allow the SV2M project, and the impacts to a range of environmental features and factors if the project was approved and built, as is typically done in a NEPA (National Environmental Policy Act) compliant EIS.

Color selection was a key part of the visual resource analysis in the EIS for the SV2M project. An in-depth analysis of the existing landscape was conducted to determine the most appropriate color for transmission structures (165-foot steel monopoles) on BLM land. Where the project was proposed, vegetation was dense and the topography was varied. These factors played into the decision to require project elements like poles to be painted in BLM standard colors that have been analyzed in various landscapes and have proven to blend well, especially in vegetated desert conditions (Fig. 5).

The EIS summarized the analysis this way:

The color of the structures or lattice towers affects how well the structure blends in the environment. Photographs of boards treated with the BLM's standard environmental colors were taken from KOPs [key observation points] representing typical topography and vegetation within the project area. The photographs were then analyzed to identify which standard environmental color would minimize visual impacts. While no one color works best in all situations and lighting conditions, the shadow gray and shale green colors blended best under front lit conditions and had low levels of contrast in back lit situations (Bureau of Land Management 2013).

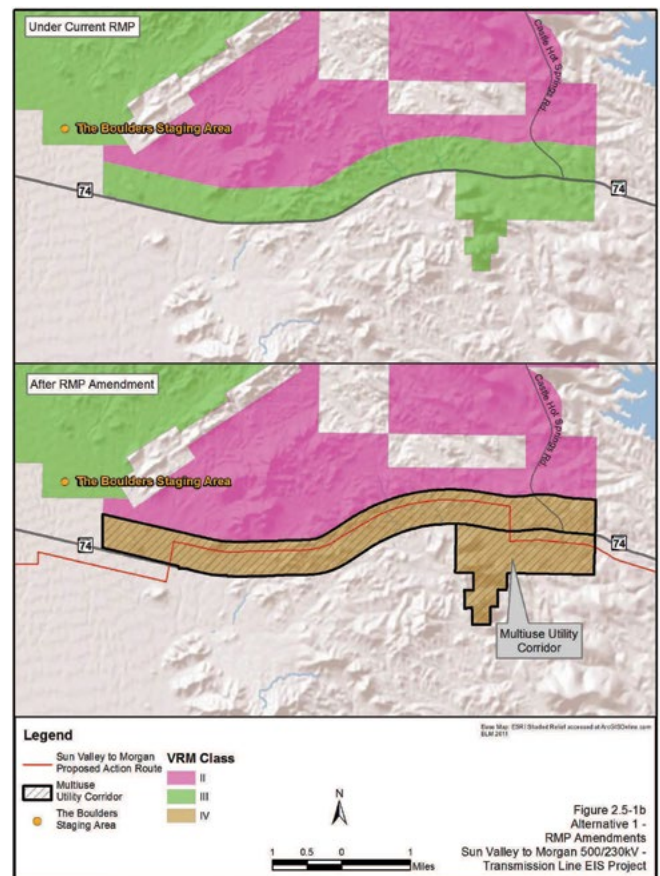


Figure 4.—Proposed RMP amendment. Source: Bureau of Land Management 2013.



Figure 5.—Existing landscape of SV2M project area. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 6.—Valmont galvanized steel samples overlaid onto BLM standard color chart. Photo by Brandon Colvin, U.S. Bureau of Land Management.

Unfortunately, conflicting language was also included in the EIS:

Surface treatment options for monopole structures are very limited and do not achieve much color variation. The colors available would be shades of gray ranging to almost black; no surface treatments available would resemble shale green (Bureau of Land Management 2013).

This language left a discrepancy to be worked out by the project team. In addition, the visual simulations produced as part of the EIS had only simulated a light galvanized steel finish. This made it very difficult to demonstrate the value of the shale green or shadow gray colors on the structures. Despite these conflicts, ultimately the BLM maintained the authority to approve the color of the structures (Bureau of Land Management 2014).

COLOR SELECTION MEETING

A meeting was held to discuss the color options for the steel monopoles. Valmont Industries, Inc. (Valmont), the manufacturer on contract to produce the steel monopoles, provided three samples of galvanized steel as options for the project: light, medium, and dark galvanized finishes (Fig. 6).

APS and Valmont hoped to receive BLM approval to use one of the colors shown in the samples, but the

samples did not match the BLM shadow gray or shale green colors.

RESEARCH ON COLOR TREATMENT OF TRANSMISSION STRUCTURES

During the initial meeting, one of the main points of disagreement was the claim that variations in color were not possible for steel monopoles. To research this issue, I contacted steel transmission structure manufacturers throughout the United States, inquiring about their ability to color treat monopoles. While none claimed that this was a common practice, they did confirm that it was possible. In fact, some manufacturers market their ability to color treat these types of structures on their Websites.

In addition, over the years, I have photographed many examples of color treated monopoles in various U.S. States while traveling for work. See, for example, Figure 7.

Having successfully identified transmission line projects across the western landscapes that were color treated, and strongly believing that color treating the monopoles for SV2M was necessary to properly reduce visual impacts, I set out to demonstrate the benefits that could be achieved by using color treated monopole structures.



Figure 7.—Color treated monopole in Boise, ID. Photo by Brandon Colvin, U.S. Bureau of Land Management.

PROJECT VISUAL SIMULATIONS

For SV2M, the visual simulations, though only shown with a light galvanized material, proved that visual simulations can contribute to making successful mitigation decisions for a project. The simulations demonstrated the location of the project, what the structures and lines would look like, and the contrast these project elements would have with the surrounding landscape (Fig. 8a). Unfortunately, they did not portray the colors that had been selected to reduce contrast and visual impacts in the analysis, so they were only useful to a certain degree.

Starting with the original simulations from the EIS, I developed multiple simulations in Adobe Photoshop, using various overlay techniques to simulate color treatment with the shale green, shadow gray, and weathered steel color tones. As seen in Figure 8b, the weathered steel does bring a more natural look to the monopole structures but it is still highly noticeable, drawing viewers' attention.

The next simulation used a shale green/shadow gray tone (Fig. 8c). These colors clearly performed the best against the existing natural landscape.

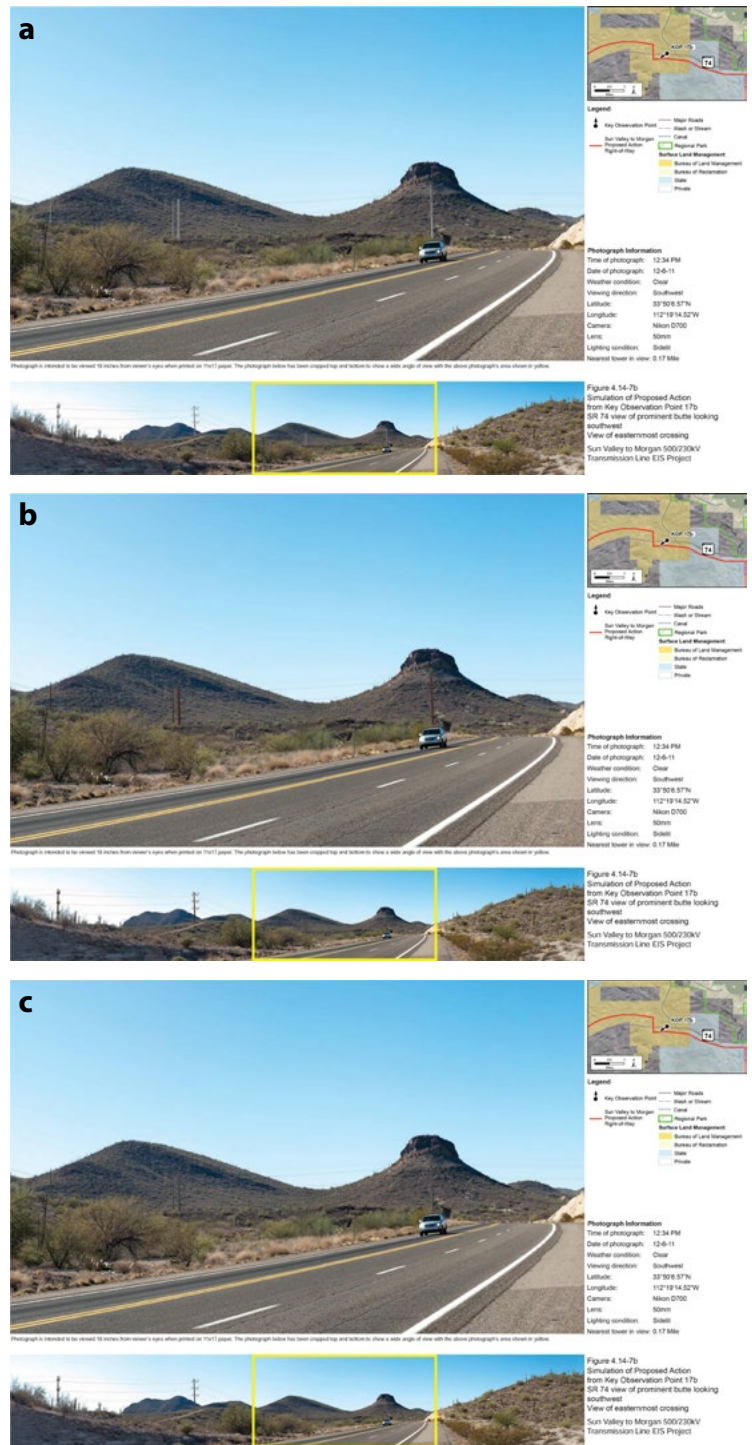


Figure 8.—Simulation of Sun Valley to Morgan 500kV Transmission Line using a) galvanized steel; b) weathered steel; c) shadow gray/shale green. Source: Bureau of Land Management 2013.

While these simulations provided good source images to gauge the performance of each color in the existing conditions, the BLM team decided to assess these colors in the field with actual product samples.



Figure 9.—Sample poles from Valmont for review by BLM. Photos by Brandon Colvin, U.S. Bureau of Land Management.

SAMPLE POLE FIELD ASSESSMENT

Once samples poles from the manufacturer were in place, the BLM team visited the field site in the morning hours as well as the afternoon to ensure that we experienced a range of lighting conditions (Fig. 9). The team quickly decided that the weathered steel finish was not a viable option. The color contrast with the surrounding landscape was just unacceptable. The galvanized material finishes were no better. They had a significant amount of reflectivity and did not blend with the surrounding landscape. They also did not match the shadow gray or shale green color boards.

We learned through this onsite assessment that the shale green and shadow gray colors, as described in the EIS analysis, blended very well with the surrounding landscape. Shale green has a slightly more gray-green base and performed especially well against the dense vegetation.

After viewing the samples both in the morning and afternoon hours, capturing images looking in eastern and western directions, it was clear that the BLM standard color shale green performed the best in this landscape condition.

VISUAL SIMULATIONS DEVELOPED USING ADOBE PHOTOSHOP

As a followup to the field tests, using various techniques and tools in Adobe® Photoshop®, I developed some rough draft visual simulations that would more accurately portray the monopole structures color treated with shale green. I also included shadow gray in the simulation. Figures 10 through 12 show a progression of simulations that I developed. They make it even more apparent that shale green was the appropriate color selection.



Figure 10.—Condition existing prior to simulation. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 11.—Simulation part 1. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 12.—Completed simulation matching color boards. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 13.—Natina Steel sample. Photo by Brandon Colvin, U.S. Bureau of Land Management.

After careful consideration and discussion among BLM staff, BLM informed APS that shale green was the approved color for the monopole structures. The method of color treatment was left to the discretion of APS, as long as it was a durable, non-reflective surface. Though this would add cost and complexity to the project, APS understood the sensitivity of the resources at hand and agreed to proceed with the shale green color treatment of the monopole structures on the BLM portion of the project.

ALTERNATIVE MATERIAL FINISH ANALYSIS

Shortly after APS learned about BLM's selection and approval of the shale green color, APS was contacted by Natina Products (Natina), a company that color treats steel with a different type of chemical finish. Natina and APS discussed the possibility of using a product such as Natina Steel to color treat the steel monopoles. Though Natina's desert varnish color was not a match for the BLM shadow gray or shale green, the BLM team felt that it would be of value to review a sample of Natina Steel at the project site (Fig. 13). The potential advantage of this type of material finish was that it was not an additional coating or layer on top of the steel. The product reacts directly with the galvanized steel so was expected to age well.

Upon initial review, it appeared that Natina Steel would be a good option. The material had a low level of contrast in the immediate foreground and seemed

to blend well with the soil and scattered rock. But the team concluded that it would be helpful to review additional simulations to compare the BLM shadow gray and shale green with the Natina Steel finish. Figures 14 through 16 show the progression of this simulation, starting with the new sample material, and comparing that to similar examples using the shale green and shadow gray colors.

The Natina Steel sample did blend well with the existing natural landscape, especially in the immediate foreground. However, it did not perform as well when the pole was in the background. That pole is the only structure clearly visible in the background of the photo while the shadow gray and shale green both appear to fade from visibility.

INITIAL COLOR TREATED SAMPLE STEEL PANELS

Within a few months, APS had received steel panel samples (24 inches × 48 inches) that had been powder coated with shadow gray and shale green. They also provided standard galvanized steel panels for BLM review (Figs. 17, 18).

We transported these samples to the original site where we had conducted the onsite assessment to keep a consistent landscape for evaluation. It was amazing how well the color treated steel panels matched the BLM color boards. It was also clear that these colors blended very well with the surrounding landscape.



Figure 14.—Condition existing prior to simulation. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 15.—Simulation showing Natina steel, shadow gray and shale green. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 16.—Simulation of selected color shale green. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 17.—Sample galvanized steel and powder coated panels. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 18.—Sample powder coated panels. Photo by Brandon Colvin, U.S. Bureau of Land Management.



a



c



b



d

Figure 19.—Monopole production at Valmont manufacturing: a) welding; b) steel work complete; c) ready for powder coat; d) ready for transport. Photos by Brandon Colvin, U.S. Bureau of Land Management.

SITE VISIT TO VALMONT MANUFACTURING FACILITY

In the summer of 2016, the BLM was notified that production had started on the shale green powder coated monopoles. I joined APS staff on a site visit to the Valmont manufacturing facility in Nebraska.

This provided a great opportunity to witness the pole manufacturing process, from initial steel shaping and welding, all the way through final finish powder coating and transport. Figure 19 shows some of the stages of production.

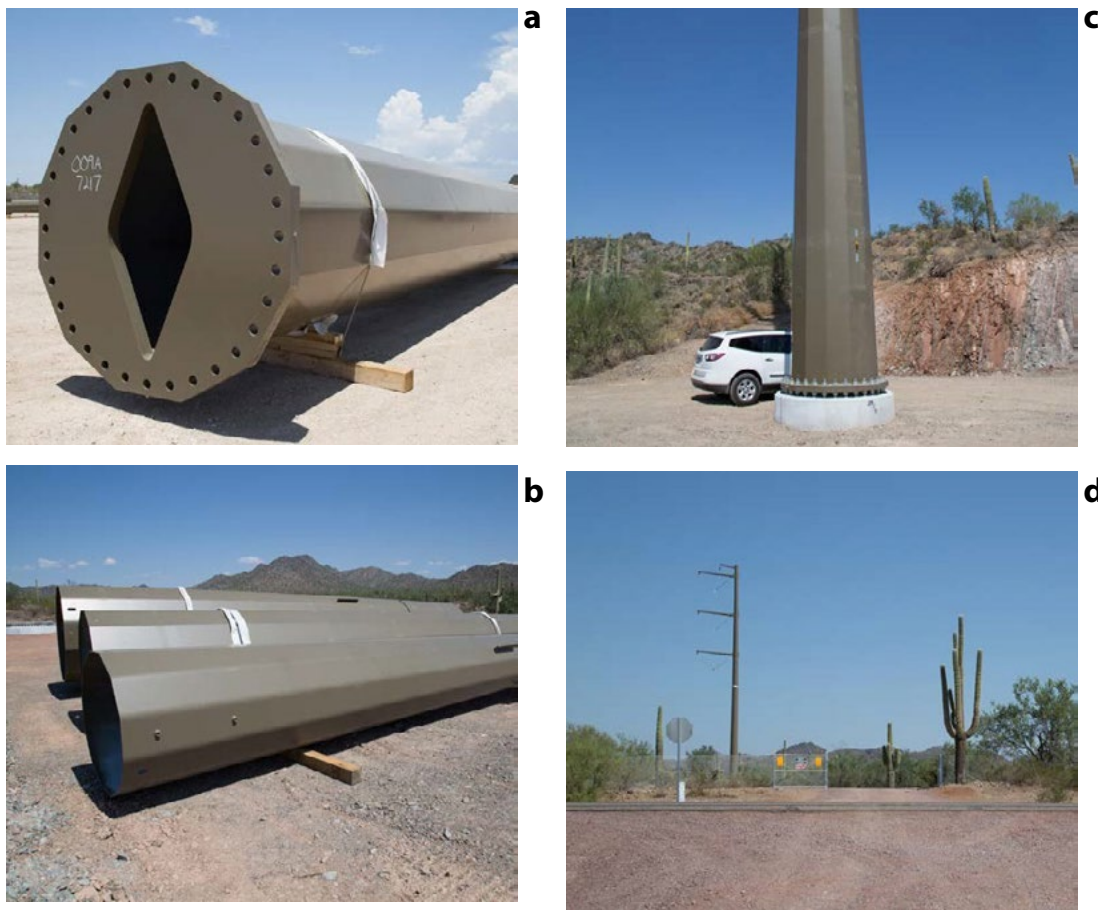


Figure 20.—Construction of the Sun Valley to Morgan 500kV Transmission Line began; a) powder coated monopole at staging yard; b) staged for placement; and c and d) erected. Photos by Brandon Colvin, U.S. Bureau of Land Management.

CONSTRUCTION PHOTOS

As of this writing, construction of the SV2M has been underway for a few months and some of the shale green powder coated poles have been installed (Fig. 20). They perform even better than expected. The poles are still noticeable from certain vantage points and are clearly seen when they are above the horizon (Fig. 21), but in all situations they fit into the landscape more appropriately than any of the other options.

The true test of the success of the color selection for these monopoles is when the structures are backdropped by the surrounding mountains (Fig. 22). In this scenario, the poles blend almost completely into the landscape. The galvanized pole on the right side of the image clearly stands out and attracts attention. The powder coated poles in the center and left side of the image often go completely unnoticed. This is exactly what BLM was working to achieve.

CONCLUSION

With so many energy transmission lines being constructed across the United States, many on public lands, it is important that we use readily available tools to simulate the visual aspects of these projects to make more informed project decisions. While simulations are often used in project analysis and assessment, they are rarely used in the initial stages of project planning and design. This leads to missed opportunities to use visual simulations to make informed decisions about what aspects of a project can be modified to reduce impacts to resources.

As the current trend of energy transmission development shows no signs of slowing in the near future, we must use simulation techniques to reduce the visual impacts of these projects. With some basic Photoshop skills, a little time, and some persistence in working with proponents, we can develop energy infrastructure that meets the needs of the public while preserving the natural scenic character of our amazing public lands in a more sustainable way.



Figure 21.—Powder coated monopoles with back lighting. Photo by Brandon Colvin, U.S. Bureau of Land Management.



Figure 22.—Powder coated poles front lit from same perspective as simulations. Photo by Brandon Colvin, U.S. Bureau of Land Management.

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