National Park Service
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Natural Resource Stewardship and Science

Guide To Evaluating Visual Impact Assessments for Renewable Energy Projects

Natural Resource Report NPS/ARD/NRR—2014/836





ON THE COVER
Views of renewable energy and electric transmission facilities
Credit: Argonne National Laboratory

Guide To Evaluating Visual Impact Assessments for Renewable Energy Projects

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Abstract

Utility-scale renewable energy projects are increasingly being proposed and sited near units of the National Park System and other special status areas under the stewardship of the National Park Service (NPS). In carrying out its responsibilities, the NPS evaluates the potential impacts of renewable energy projects on park resources, including scenic views, and works with permitting agencies and project developers to avoid and/or mitigate impacts on park resources. The *Renewable Energy Visual Impact Assessment Evaluation Guide* (the Guide) presents detailed information to assist park and regional resource managers in evaluating the adequacy of visual impact assessments (VIAs) covering proposed utility-scale renewable energy projects and to help them identify and understand the potential impacts those projects may have on nearby scenic views. Renewable energy project types addressed in the document include wind energy (onshore and offshore), solar energy, and electric transmission projects.

Topics covered include:

- A summary of the renewable energy project siting and approval process for federal agencies;
- Proper interpretation and critical assessment of the completeness and accuracy of a VIA document;
- Assessment of visual impacts associated with power generation and transmission components; and
- Evaluation of the quality and accuracy of visual simulations of proposed projects.

The goal is for users of the Guide to become better informed and more articulate in ensuring that visual resource protection is properly considered in project siting and permitting decisions.

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National Park Service Reviewers

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Acronyms and Abbreviations

AVWS	Audio Visual Warning System
BLM	Bureau of Land Management
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
CEQ	Council on Environmental Quality
COP	Construction and Operations Plan
3D	three-dimensional
DEM	Digital Elevation Model
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EA	Environmental Assessment
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
ft	foot (feet)
GIS	geographic information system
GPS	global positioning system
in.	inch(es)
KOP	key observation point
kV	kilovolt(s)
LORS	laws, ordinances, regulations and standards
m	meter(s)
mi	mile(s)
mm	millimeter(s)
MMS	Minerals Management Service
MW	megawatt(s)
NED	National Elevation Dataset
NEPA	National Environmental Policy Act of 1969

NHPA	National Historic Preservation Act of 1966
NOI	Notice of Intent
NPS	National Park Service
NRHP	*National Register of Historic Places*
NZILA	New Zealand Institute of Landscape Architects Education Foundation
OCS	Outer Continental Shelf
POD	Plan of Development
PV	photovoltaic
ROD	Record of Decision
ROW	right-of-way
SAP	Site Assessment Plan
SEM	Surface Elevation Model
SLR	single-lens reflex
SMS	Scenery Management System
STG	steam turbine generator
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
VIA	visual impact assessment
VRI	Visual Resource Inventory
VRM	visual resource management

Evaluating Visual Impact Assessments—Quick Reference

The *Guide to Evaluating Visual Impact Assessments for Renewable Energy Projects* (the Guide) is a comprehensive resource for understanding how to assess the quality of visual impact assessments (VIAs) that the National Park Service (NPS) must review for potential visual impacts on park scenic views that extend beyond park boundaries. The introduction in Chapter 1 includes a brief overview of the Guide's purpose, intended users, and document structure. This Quick Reference is intended to provide a summary of key elements in the Guide and to direct readers to locations in the Guide for more detailed information.

Readers seeking an overview of the process for evaluating a VIA document and the general project development process should read Chapters 1, 2, and 3. Those who will actually be reviewing VIAs are urged to read and use the full document. Chapters 4 and 5 focus on VIA review and comment preparation.

	What Is a Visual Impact Assessment?
Chapter 1, Sec. 1.4 Chapter 3, Sec. 3.2	A visual impact assessment (VIA) is a technical analysis of the visual impacts of a proposed project. A VIA typically includes a description of the project, the visual landscape, and important scenic resources. It also includes visual simulations that show what the project will look like, a description of potential project impacts, and mitigation measures that would help to reduce the visual impacts created by the project.
	Project Permitting
Chapter 2, Sec. 2.1–2.7	For projects located at least partly on federal land, the right-of-way (ROW) grant process of the lead federal agency determines the project schedule and the environmental analysis. The generalized process for projects on federal lands includes the following: 1. The developer conducts project studies to determine the location and size of the project. 2. The developer and federal agency hold pre-application meetings to discuss the proposed project. 3. The developer files an application for the project and submits a Plan of Development (POD). 4. Typically, an environmental impact statement (EIS) must be prepared for the project based on the project description in the POD. The EIS includes analysis of project alternatives. The project development and permitting process for offshore wind projects differs from onshore projects in that the Bureau of Ocean Energy Management (BOEM) selects offshore areas for development. For projects on non-federal lands and waters, the permitting process is highly variable. A project that does not involve federal lands or waters or the need for federal permits often does not require the preparation of a VIA.
	NPS Involvement
Chapter 2, Sec. 2.8	Opportunities for early engagement to ensure National Park Service (NPS) concerns are addressed include: • Providing data such as viewpoint locations, viewshed information, and other GIS data. • Attending project meetings where visual resources will be discussed. • Maintaining a comprehensive project file to document how the analysis proceeded. • Assisting the lead agency and contractor in developing mitigation measures.

	Visual Impacts
Chapter 3, Sec. 3.1	Chapter 3 provides an overview of a VIA—why the analysis is important and the steps for preparing one. This section also explains what visual impacts are, the changes to the scenic attributes of the landscape brought about by the introduction of visual contrasts from a proposed project, and the associated changes in the human visual experience of the landscape. • *Visual contrast* is change to what is seen by the viewer. • *Visual impact* is both the change to the visual qualities of the landscape resulting from the visual contrasts and the human response to that change.
	Purpose of a VIA
Chapter 3, Sec. 3.1	Chapter 3 also provides an overview of the purpose of a VIA, including identifying and describing the visual contrasts caused by a proposed project, assessing the impacts on viewers, and identifying mitigation to reduce impacts.
	Key Steps in Preparing a VIA
Chapter 3, Sec. 3.2	While a VIA is a complex document, there are specific steps that an agency or contractor will follow in the development of the document. The key steps are listed below and described in more detail in the section noted. • Gathering information about the regional and project landscape setting. • Reviewing relevant planning and regulatory documents to identify impact assessment methods. • Developing a description of the visual characteristics of a project. • Determining the potential visibility of the project through viewshed analysis. • Identifying important viewpoints or key observation points (KOPs). • Gathering and synthesizing information about viewers who would likely be viewing the project. • Preparing spatially accurate and realistic visual simulations. • Evaluating the simulations to assess the visual contrasts of the proposed project. • Determining visual impacts based on predicted visual contrasts. • Specifying mitigation actions that would avoid, reduce, or compensate for the impacts. • Determining compliance with any applicable visual resource management objectives and any applicable laws, ordinances, regulations and standards (LORS).
	Critical Elements of a VIA
Chapter 3, Sec. 3.2–3.11; Chapter 4, Sec. 4.1–4.2	The two most important parts of the VIA are the Affected Environment and the Environmental Consequences. *Affected Environment* This section describes the existing conditions against which the potential effects of a project will be assessed. It includes the applicable visual resource-related LORS and agency management objectives and also provides information about the regional and project landscape. *Environmental Consequences* This section describes the visual impacts of a project. It also includes key components such as the scope and methodology used for the impact analysis and a detailed description of the visual characteristics of each alternative. Potential impacts are described in terms of the visual contrasts created by the project components and associated activities; these are typically determined from visual simulations. This section also typically includes a description of specific mitigation measures and a discussion of compliance with all LORS and agency visual management objectives. It should also include visual objectives for adjacent lands.

	Factors Affecting the Visibility and Visual Contrasts Created by Renewable Energy Projects
Chapter 4, Sec. 4.2.4	The visibility of an object in a landscape setting and its apparent visual characteristics for any given view are the result of a complex interplay among the observer, the observed object, and various factors that affect visual perception, referred to as *visibility factors*. There are eight major types of visibility factors that affect perception of large objects in the landscape: • *Viewshed limiting factors*—variables associated with accurate viewshed analysis. • *Viewer characteristics*—visual acuity, viewer engagement and experience, and viewer motion. • *Lighting factors*—the angle, intensity, and distribution of sunlight on the project. • *Atmospheric conditions*—the presence of humidity and particulate matter which may affect visibility by diminishing contrast and subduing colors. • *Distance*—the distance between the viewer and the viewed object, which affects the apparent size and degree of contrast between an object and its surroundings. • *Viewing geometry*—the spatial relationship of the viewer to the project, that is, looking up or down at a project and the horizontal direction of the view (such as looking perpendicular to a transmission line). • *Backdrop*—the visual background against which facility elements are seen, for example, the sky or mountains. • *Object visual characteristics*—the inherent visual characteristics of the project, such as the facility and structure size; the scale relative to other objects in view; the form, line, surface colors, and textures of the facility components; and any visible motion of the facility components.
	Primary Visual Contrasts Associated with Renewable Energy Facilities
Chapter 4, Sec. 4.2.5–4.2.8	Visual contrasts are usually described in terms of four design characteristics—Form, Line, Color, and Texture. Typical sources of visual contrast associated with projects include: • Vertical line contrasts associated with wind turbine towers, solar power towers, and transmission towers; • Color contrast from the white tower and blade structures of wind turbines, and the varying colors of solar arrays. • Scale contrasts of the height of individual wind turbines and solar power towers, and the large expanse of the wind turbine and solar panel arrays. • Motion of the wind turbine blades or steam vapor plumes. • Line, color, and texture contrasts from roads and other areas cleared of vegetation. • Form, line, and color contrasts from substations. • Color contrast from aviation obstruction lighting and other facility lighting at night. • Glare and glinting from solar collectors/reflectors.
	Visual Simulations
Chapter 5, Sec. 5.1	In the context of professionally prepared VIAs, visual simulations are visualizations (typically computer-generated) of the proposed project and surrounding landscape that are used to depict the overall appearance of a proposed project after it is operational. The sections below provide an overview of what makes a good simulation as well as the limitations and sources of error associated with trying to simulate what a project would actually look like.

	Visual Simulations
Chapter 5, Sec. 5.2	***Traits of good simulations*** • Simulate the actual or expected appearance of the landscape and project as closely as possible, according to the data available at the time. • Represent the important and typical range of views which would be experienced with the actual project, under a wide a range of viewing conditions. • Properly prepared and displayed such that project components and the surrounding landscape are depicted clearly
Chapter 5, Sec. 5.5	***Important limitations of simulations*** • **Loss of dynamic visual experience.** The human visual experience changes constantly as the viewer moves and as elements of the project move or change their appearance over time. Simulations based on photos cannot capture the dynamic visual experience. • **Limitations to contrast range.** A camera cannot capture the same range of visual contrast as the human eye, and simulations based on photography often under-represent visual contrasts of projects. • **Limits to the field of view.** Photographs have a limited and predetermined field of view and cannot capture the full field of human view unless panoramic images are used. • **Limited viewpoints.** Simulations developed for views from KOPs only depict the views from those locations and omit many other potential views of the project. • **Viewing distance requirements.** Simulation must be viewed at a specific viewing distance to see the project at the same size as it would be seen in the real landscape.
Chapter 5, Sec. 5.6	***Common sources of error and inaccuracy in simulations*** • **Improper selection of KOPs and simulation parameters.** Improper selection of KOPs may limit viewers' knowledge of the full range of visual impacts or may bias the assessment by not showing or fully disclosing important impacts. • **Spatial inaccuracy.** Spatial inaccuracy in simulations results from omitting elements that would be visible in the real landscape; showing elements that would not be visible; or showing objects in the wrong location or wrong sizes. • **Lack of realism.** A simulation may be spatially accurate but not realistic; that is, the project elements do not look the way they would in a real view of the project. • **Improper display**. Simulations must be displayed properly for accurate impact assessment and for stakeholder information purposes. • **Improper documentation.** Sound methodology and supporting documentation are required for producing defensible simulations in VIAs.

1. Introduction

The National Park Service (NPS) *Guide to Evaluating Visual Impact Assessments for Renewable Energy Projects* (the Guide) has been developed to assist park and regional resource managers in evaluating the adequacy of visual impact assessments (VIAs) for proposed utility-scale wind and solar projects and electric transmission lines outside park boundaries. It will assist NPS staff in identifying and understanding the potential impacts that those projects may have on nearby park scenic views, including those that extend beyond park boundaries. Those assessments typically include visual simulations of what a project is anticipated to actually look like if approved and built. While this guidance document is not meant to make you an expert, it is meant to provide you with a basic understanding of the components of a VIA and what constitutes a good analysis and presentation. The focus is on how that assessment should account for impacts on the scenic views from National Park System units and other special status areas. If you are faced with having to review such an assessment and need help, please contact the Visual Resource Specialist in the Air Resources Division of the Natural Resource Stewardship and Science Directorate.

The development of the Guide is just one small part of the effort to assist park and regional resource managers in collaborating with others in protecting park scenic views now and into the future. The Guide is a work in progress. As such, we welcome feedback on how to enhance its use.

The sections below present the need and purpose for the Guide, its scope, intended use and users, and how it is organized.

1.1 Need and Purpose for Document

As a nation, we have made dramatic steps toward diversifying our energy portfolio to include utility-scale renewable energy projects.[1] Some of these projects have been proposed and sited near national parks, national historic and scenic trails, and other protected areas. As a result, park and regional staff have needed to evaluate the potential impacts on park resources, including scenic views, and to advocate for needed mitigation, including alternative siting locations. Visual impacts on a park unit from solar, onshore/offshore wind, and electric transmission projects can occur when the projects are located on nearby lands or waters and are visible from viewpoints within that unit that are important to the unit's resource values and to the visitor's experience. Modern utility-scale wind and solar facilities tend to be very large, with particularly noticeable and often striking visual characteristics.

[1] There is no industry standard definition of utility-scale projects. For purposes of this guidance, utility-scale refers to any project planned solely for the commercial generation of electricity to be supplied to the local, regional, or national electrical transmission grid. Generally, these projects will be planned to have about 10 MW of generating capacity or more.

Because these types of facilities are fairly new, NPS staff may lack experience in dealing with such large projects and disclosing the unique visual impacts they can cause.

While developers routinely prepare VIAs for utility-scale renewable energy projects, the quality of the documents and the analyses can vary greatly. This technical guidance document is meant to assist NPS staff in understanding and evaluating the quality of VIAs conducted for proposed projects on nearby lands, so that they can provide credible and substantive feedback and comments through the environmental review process.

The purpose of the Guide is threefold:

1. Facilitate systematic and thorough review of VIAs for onshore/offshore wind, solar, and transmission facilities and their associated infrastructure;
2. Provide the basis for active and informed participation of NPS staff and partners in the VIA and mitigation process; and
3. Lead to improved analysis of visual impacts of renewable energy facilities.

In providing this support for evaluation of the potential impacts on the scenic landscape,[2] the ultimate goal of the Guide is to help NPS resource managers achieve better outcomes that protect park scenic views and perhaps ultimately improve the design and siting of utility-scale projects, including transmission lines, to better account for the need to protect the scenic views associated with our national parks and other special status areas of national importance.

1.2 Scope

The Guide has been developed to assist in the evaluation of VIAs that are prepared for utility-scale renewable energy projects, including onshore and offshore wind and solar energy facilities. High-voltage transmission line facilities are also included because the development of renewable energy projects requires additional transmission facilities to get the electricity they produce to markets. Wind and solar projects are often built in remote locations and require the development of high-voltage transmission lines and substations to connect the projects to the electrical grid. In addition, completely new, cross-country lines that will be new components of the national grid are being built to transport electricity regionally.

This document provides guidance on:

- Reviewing VIA documents, or the visual resource components of Environmental Impact Statements (EISs), and correctly interpreting and critically assessing the completeness and accuracy of a VIA document;

[2] In this document, the term “landscape” is used to refer both to landscapes and seascapes, including lakes.

- Assessing impacts associated with power generation and transmission components (i.e., energy collectors) and directly associated infrastructure (e.g., steam plants, inverters, and substations); and
- Evaluating the quality and accuracy of visual simulations of proposed utility-scale renewable energy projects.

This document does not:

- Provide guidance on engaging with developers and other land managers on siting decisions—a proposed site has already been chosen once the VIA is developed.
- Provide instruction on preparing VIAs, nor does it present detailed information on renewable technologies. Basic information on renewable technologies is provided to aid in understanding a project's visual characteristics.
- Provide guidance on identifying or evaluating viewsheds that may be affected by utility-scale renewable energy projects. NPS is currently developing a systematic approach for the inventory and evaluation of scenic views to assist parks in this process.
- Provide guidance on evaluating VIAs for consistency with Director's Order 12 (NPS 2011). The VIAs discussed in the Guide are not NPS-generated National Environmental Policy Act of 1969 (NEPA) documents, and the structure and terminology of a VIA, whether a stand-alone report or within an EIS, will not likely be consistent with an NPS document.

1.3 Context: Legislative and Policy Direction

Congress established the NPS to "promote and regulate the use of the Federal areas known as national parks to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Title 16, Section 1, *United States Code* [16 USC § 1]). Scenery is clearly an important value for the NPS to protect. Congress also specifically mentioned scenery when establishing many individual park units. The 2006 NPS Management Policies reiterate this mandate: scenery is the first listing under *What Constitutes Park Resources and Values* (Section 1.4.6). The Management Policies also recognize, in several sections (1.6, 3.1, 4, 4.1.4, and 4.71), that NPS is to work cooperatively beyond park boundaries to protect resources such as scenic views. In addition to units of the National Park System, the NPS also provides leadership for the stewardship of other special status areas like national historic and scenic trails, wild and scenic rivers, and a broad array of cultural resources, including cultural landscapes—where scenery also plays a critical role in understanding and experiencing these areas and resources.

1.4 VIAs and the Planning Process

The term, "visual impact assessment (VIA)," is used in the Guide as a generic term to refer to the analysis of the visual impacts of a proposed project. A VIA is often prepared as a stand-alone technical report early in the planning of a project, along with other resource reports such as biological or cultural resource surveys. At present, no industry-wide standard exists for the title or content of a VIA. It may be called a "Visual Impact Analysis," "Visual Impact Assessment," "Visual Resource Technical Report," or another name that identifies it as a technical document for the evaluation of visual impacts for a specific project. The term "VIA," as used throughout this document, refers to either a stand-alone VIA report or the visual resource section of an EIS. The following are some key points to understand about the relationship of the VIA to the planning process.

- The scale, complexity, and level of potential environmental impacts of utility-scale renewable energy projects will typically require the preparation of an EIS. However, in some cases, visual impacts for a utility-scale project may be addressed by an Environmental Assessment (EA).
- As a project proceeds, the information from the VIA is incorporated into the EIS. If the NPS is engaged in the planning process early enough, staff may be asked to review the VIA as a stand-alone report. More often, NPS staff will be reviewing the impacts on visual resources in the EIS, perhaps at the Administrative Draft stage or at the Public Draft EIS review stage.
- A VIA will sometimes be attached to the EIS as an appendix, and the visual resource section of the EIS will be a summary of the VIA. All of the components described in this guidance should be found either in the VIA or in the EIS.
- Review of, and comment on, the VIA as a stand-alone report **does not ensure that concerns will be addressed in the EIS**. The stand-alone VIA is not a NEPA document, and no decision is made by the lead agency based on this document alone. It is important for NPS staff to stay engaged and review the EIS whenever possible to ensure that concerns are addressed.

1.5 Intended Users and Uses

The Guide is intended to assist in the review of VIAs for utility-scale renewable energy projects on lands near park units and other special status areas. It is primarily intended for use by NPS staff charged with reviewing these documents to make it easier for them to determine the completeness and accuracy of VIAs (including simulations) submitted by applicants or other parties.

While written from an NPS perspective, the Guide is not intended for internal use only. It may be shared with other agencies, non-profit groups, and contractors and developers associated with renewable energy projects, as they may find it useful in understanding NPS expectations for the content and quality of a VIA document.

1.6 Organization of Document

This remainder of the Guide is organized into six main sections and also includes appendices to provide more detailed information on certain topics, as well as checklists for use in reviewing VIA documents.

- **Chapter 2** contains a brief overview of the general siting and permitting process for utility-scale renewable energy and electric transmission projects. It provides a generic framework for the steps in the project development process so that NPS staff understand the opportunities they have to become actively engaged during project review.
- **Chapter 3** provides an overview of the VIA process that covers how the potential visual impacts of a project are

> **TIPS**
>
> *Helpful tips throughout the Guide highlight key points and suggest ways for NPS staff to be more effective participants in the VIA process.*

determined. It discusses the key steps in the VIA process, including describing the existing landscape, the proposed project, the viewers, and project viewpoints; how visual contrast and impacts are determined; the use of visual simulations; and the specification of mitigation measures.

- **Chapter 4** provides a more detailed review of the components of a high-quality VIA and the visual impact section of an EIS. It examines each section of the VIA/EIS discussion and discusses the important content that should be included. It also includes discussion of the visual contrasts associated with wind, solar, and transmission projects.
- **Chapter 5** discusses the use of visual simulations in a VIA. It provides an overview of how simulations are used and prepared, discusses how to interpret the information displayed in a simulation, and how to assess the quality and accuracy of simulations of a proposed project.
- **Chapter 6** lists cited references.
- **Chapter 7** contains a glossary of terms.
- **Appendices A through D** include additional information about viewshed analyses; visibility factors; checklists for VIA components, mitigation measures, and visual simulations; and summaries of relevant renewable energy and electric transmission visibility studies.

Throughout the document, helpful tips highlight key VIA concepts and specific actions NPS staff can take to become more effective participants in the VIA and project development process.

2. Siting and Permitting Process and Regulatory Requirements for Visual Impact Analyses

This chapter provides an overview of how renewable energy facilities are sited and permitted and includes a brief discussion on the regulations/requirements that may affect the conduct and content of VIAs. The permitting and review process of agencies can often change, so it is important for NPS staff to make sure they know the current requirements under which a project is being developed to allow for timely and effective input.

Whatever the process, NPS staff are encouraged to get involved at the earliest stage possible and maintain continuous involvement throughout to achieve better outcomes. While this technical document does not provide guidance on how to become involved in the early siting stages, some basic information on the siting process is provided for context, and opportunities for involvement in other aspects of VIA are identified.

As of 2014, there is preliminary discussion among several agencies about consolidating and streamlining the permitting process, resulting in a single permitting approach. This document will be updated to reflect any process changes in the future. This section presents a general overview of existing permitting processes.

2.1 Project Siting

Developers of renewable energy facilities are usually specialized and will normally identify a good site to develop a specific technology, rather than selecting a site and then determining what kind of project to build. While the specific needs of a project may vary, the general considerations in the site selection process for solar, onshore wind, and transmission projects are outlined below. During the site selection process, the developer performs preliminary design and engineering analyses to assess constructability and costs. These analyses will address the following issues:

TIP

Members of the NPS external Renewable Energy Team are available to help you understand the permitting process. With special visual impact questions, be sure to contact the Visual Resource Specialist with the NPS Air Resources Division.

- **Identification of areas with sufficient energy resources.** Minimum requirements for wind speed or days of sunshine must be met to make it feasible for the proposed technology to generate the desired amount of electricity.
- **Appropriately sized site.** Most projects are best suited to large contiguous blocks of land. Environmental analysis of a site that is larger than needed allows for some flexibility in facility siting to reduce conflicts during project design or for incorporating on-site mitigation measures.
- **Topography and landform.** Areas of low slope with small drainage corridors are generally preferred to reduce construction costs, especially for solar facilities. Wind projects can be sited in variable terrain and are often sited on ridge lines or other higher elevation areas where there is greater wind speed.
- **Access.** Proximity to railroads and suitable existing roads will affect construction costs.

- **Environmental conditions.** Drainage, soils, or geologic conditions could affect construction methods and costs. If the proposed project site contains sensitive biological, cultural, or other resources or is in proximity to special status areas like national parks and trails, it could affect facility siting, delay the project schedule, or require expensive mitigation.
- **Proximity to transmission lines.** Projects that are distant from the main transmission system may incur increased costs from the construction of longer transmission lines needed for connecting to the main system, as well as increased planning costs and schedule implications from the requirements for more extensive permitting and environmental review.
- **Review of the land management agency's land use or resource management plan.** For projects located on federal lands, if a land use plan amendment would be required to obtain the right-of-way (ROW), it could delay the project schedule.
- **Human Factors.** Proximity to residences or communities is considered in the site selection process. Concerns included shadow flicker, scenic impacts, noise from wind turbines, and glare from solar facilities.

Offshore wind projects may be located on the Outer Continental Shelf, or OCS (generally more than 3 mi from the coast) or within state-managed waters (generally within 3 mi of the coast). For offshore wind projects located on the OCS, the site selection process is initially directed by the U.S. Department of the Interior (DOI)'s, Bureau of Ocean Energy Management (BOEM). The general leasing process and identification of areas available to developers in federal waters is explained in the BOEM permitting process discussion in Section 2.3, and an overview of siting and permitting of projects on non-federal lands and waters is presented in Section 2.4.

2.2 Project Permitting—Projects Based on Federal Lands

A renewable energy project is likely to require many permits and approvals prior to construction. For projects located either all, or partly, on federal land, the primary process that will determine the project schedule, as well as the environmental analysis and submittal requirements, will be the ROW grant process of the lead federal agency—often the Bureau of Land Management (BLM) or the U.S. Forest Service (USFS). For example, Figure 2.2-1 shows the general steps in the current BLM project ROW grant process, followed by a brief explanation. This overview is based on the requirements of an EIS because that is the NEPA analysis required for most utility-scale renewable energy and electric transmission projects. It is important for NPS to contact the lead agency as early in the planning process as possible to learn about the detailed steps and schedule of a specific project.

During the project study phase, the project developer assesses the potential demand for a project and its projected size, performs the studies to determine the location of the project (including alternate routes for a transmission line), and prepares preliminary engineering and design plans. The developer may also make informal contacts with the land management agency, as part of the resource management plan review, to assess potential support or challenges for the project.

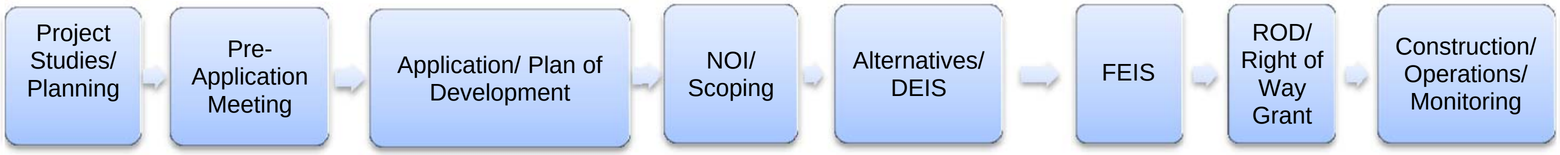

Figure 2.2-1. Generalized ROW Grant Process

2.2.1 Pre-Application Meeting(s)

Current BLM guidance requires two pre-application meetings prior to submitting an application for a ROW grant. One of the meetings may include other federal agencies (like the NPS) to alert prospective applicants of issues and concerns. The items to be discussed at the pre-application meetings include the scope of the proposed project; the proponent's public outreach; the financial and technical capability of the proponent; the conformance of the project with current land use plans; potential environmental and siting constraints; compliance with NEPA and other laws; special resource protection considerations; the potential timeframes and schedule for filing an application; and the proponent's planned public outreach activities.

2.2.2 Application/Plan of Development

For a BLM and USFS ROW grant, the application is accompanied by a Plan of Development (POD) that provides a detailed description of the project. The development of the POD includes extensive work by the project developer to prepare the preliminary design and engineering for the project.

2.2.3 Notice of Intent/Scoping

In this phase, the land management agency will prepare and publish a formal Notice of Intent (NOI) to grant the ROW, and the formal NEPA scoping process will be started. Some project developers will have had informal scoping meetings with the various communities in the project area prior to submitting an application.

TIP

While the NOI and scoping phase are the first formal public notification, engagement with the lead agency during the planning and pre-application phases represents the best opportunity to highlight any NPS concerns for the potential visual (or other environmental) effects of the project, and perhaps to influence the design of the project as the POD is developed.

TIP

If possible, NPS staff should review the POD for the details of project design elements, construction techniques, and restoration/mitigation plans. This information may be summarized—or not addressed at all—in the VIA and EIS because it is incorporated by reference.

2.2.4 Alternatives/EIS

The next phases of the process will include the development of project alternatives that must be considered in the EIS, and development of the EIS itself, based on the project description in the POD. Given the complexity of utility-scale renewable energy projects, there may be multiple preliminary drafts of the EIS that are reviewed internally by the lead agency and possibly cooperating agencies prior to the publishing of the Draft EIS and Final EIS. These documents should address any potential impacts on park resources and ways to mitigate those impacts. The process culminates with issuance of a formal Record of Decision (ROD) to deny or to grant the requested ROW across federal lands.

> **TIP**
>
> *NPS should be present at pre-application meetings when possible and at scoping meetings to express concern for protecting NPS resources.*

2.2.5 Project Construction

While construction may take several years to complete, the ROW grant typically identifies a period of time in which construction must start or else the grant will be voided. Construction will include all project facilities, including the transmission line necessary to tie into the electricity grid (*called a generation tie line* or *gen-tie line*). The construction plan will incorporate mitigation, reclamation, and monitoring activities, and will include the timeframe for starting reclamation (which should be at most 1 year after completion of construction) and the monitoring frequency (e.g., every 5 years) to measure success of the reclamation.

2.3 Project Permitting—Offshore Wind Projects in Federal Waters

The permitting and project development process for offshore wind projects differs from onshore projects in several ways. The most important difference is the site selection process. Rather than an entirely developer-driven process, the ultimate selection of offshore areas for development is determined by BOEM. Although a project developer may bring an unsolicited proposal, thereby spurring consideration of a specific area, under BOEM’ s process, any potential offshore wind development areas are thoroughly vetted through coordination with other government entities. A public notice is also published to solicit interest and/or information from other prospective developers and the public. In BOEM’s process, there is good opportunity for stakeholder input, like having NPS identify sensitive visual settings and concerns, so that it can be incorporated into the identification of potential project areas. By getting involved, NPS can make developers and the public aware of potential issues with NPS units. It is important to note that the NEPA process is embedded in BOEM’s process at several points; thus there are opportunities for formal scoping and comments at multiple stages. Figure 2.3-1 shows the basic stages in the BOEM process, and a brief summary of each is outlined below.

2.3.1 Planning and Analysis

In the early stages of developing an offshore wind project, BOEM will often establish a BOEM State Intergovernmental Renewable Energy Task Force and engage stakeholders. This is a good

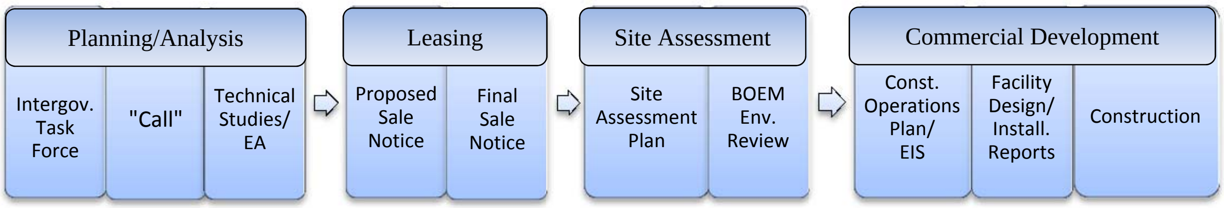

Figure 2.3-1. Generalized BOEM Offshore Permitting Process

opportunity for NPS to become involved in the planning process. In the BOEM process, determining interest in a potential development area prior to any further evaluation is done through a Call for Information and Nominations (Call). With stakeholder and developer input on the Call, potential lease areas are identified, and BOEM will typically prepare an EA to evaluate impacts associated with leasing, such as geotechnical studies and cultural and biological resource surveys.

2.3.2 Leasing

In this stage of the process, a lease for a specific area is sold to a project developer. However, prior to the issuance of a lease, BOEM prepares a Proposed Sale Notice (PSN) and a Final Sale Notice (FSN) that provide additional opportunities for NPS and stakeholder input. After the Final Sale Notice, the lease areas go through a competitive or non-competitive lease process depending on the nominations received in response to the Call. Once awarded, a lease conveys the exclusive right to submit plans required to proceed to the next stage of the process—site assessment.

2.3.3 Site Assessment and Development

The developer of a lease area conducts surveys and submits a Site Assessment Plan (SAP) that describes the installation of a meteorological tower(s) or buoy(s) that will be placed in the lease area to determine the wind energy resource within that leasehold. BOEM conducts environmental and technical reviews of the lessee's SAP, and once the SAP has been approved, the lessee may proceed with approved SAP activities. The environmental document is usually an EA and presents an opportunity to provide input through scoping.

2.3.4 Commercial Development

If the lessee decides to proceed with a commercial development, they must submit a Construction and Operations Plan (COP) to BOEM for review and approval. The COP includes design, fabrication, installation, and operations concepts as well as results of the site surveys, offshore and onshore support, decommissioning plans, and a Navigational Risk Assessment. BOEM conducts technical reviews of the COP and typically prepares an EIS for the environmental analysis, and NPS can provide input through scoping and comments on the EIS. If BOEM approves the COP, the lessee then must submit reports for approval prior to construction that detail the design and installation of the project. If BOEM finds these two reports satisfactory, the lessee will have an operations term (typically 25 years) in which to construct facilities and generate electricity.

> ***TIP***
>
> *Each stage of the BOEM process provides an opportunity for NPS to provide input into the development of an offshore energy project.*

2.4 Project Permitting—Non-Federal Lands and Waters

For projects on non-federal lands and waters that are within the viewshed of park units, the permitting process will be highly variable and will be based on the state from which the developer needs to get the permit(s) to construct the project. It is also likely that a project that does not involve federal lands or permits would not require the preparation of a VIA document. For these projects, a more indirect approach to determining a project's design and potential impacts will be required.

- Formal opportunities to participate in the planning of the project may be limited. Seeking an informal dialogue for collaboration with local agencies is critical to providing NPS an opportunity to raise potential visual concerns, along with other potential resource concerns.
- Most special use permit processes require some form of public hearing before a planning commission, utility commission, environmental department, board of supervisors, or similar body that has final decision-making authority. Those hearings provide NPS with the opportunity to make comments on a project for the public record.

> ***TIP***
>
> *Establishing and maintaining relationships with local communities are key to knowing about potential projects and having the opportunity to provide input regarding a specific project that could affect an NPS unit's viewshed.*

- In addition to the above opportunities for involvement, projects in non-federal waters are likely to require review by the U.S. Coast Guard, U.S. Army Corps of Engineers (USACE), or other maritime agencies. These entities will have their own review and approval processes, which may provide opportunities to be engaged in early in the planning, siting, and design of projects.

2.5 NPS Involvement

At the earliest stages of project development, it may be difficult to learn about potential projects. Extensive planning on the part of the project developer is required to assess the viability of a project, and much of the information is proprietary statistical data used to determine energy outputs and efficiencies. Many times, developers are cautious about making their investigations open to public or agency scrutiny before they have completed their due diligence in the planning stage.

Though often a challenge, the most important way to identify the potential impacts of renewable energy projects and participate in the project review process effectively is to become engaged and to follow through with continuous involvement. Bringing up NPS concerns early in the planning and permitting process may reduce the need for extensive mitigation to reduce visual and other impacts. In becoming engaged, NPS staff should be familiar with the viewsheds shared between the park unit and the land management agency or local entity that has land use authority over non-NPS lands within the viewshed. This will help in communicating the resource value of the scenic views to the park unit. Early involvement and follow-through will also provide the opportunity to bring additional ideas to the project that can be considered in the project design or the development of alternatives.

Understanding where potential renewable energy resource areas are located near NPS units and also within potentially sensitive viewsheds will allow NPS to provide specific and focused input to the process rather than broad general statements of potential project impacts. It is important throughout the project review process that NPS input identifies areas, such as key viewpoints, or areas with sensitive viewers that could potentially be affected by a project. The input and comments should also identify the level of use (actual numbers of users if they are available), the types of users, and their sensitivity to changes in the view at the affected viewpoints.

2.6 Federal Requirements for Scenery Management and Impact Assessment

Numerous federal laws, in addition to the NPS Organic Act (16 USC § 1), require federal land management agencies to consider scenic and aesthetic resources in land management planning, resource management, project design, implementation, and monitoring. However, there is not a specific resource protection act for visual resources. Laws requiring protection of visual resources include, but are not limited to:

- Wilderness Act of 1964
- National Historic Preservation Act of 1966
- Wild and Scenic Rivers Act of 1968
- National Trails System Act of 1968
- Clean Air Act of 1970
- National Forest Management Act of 1976
- Federal Land Policy and Management Act of 1976

NEPA does not specifically require protection of specific resources that may be identified with a project but rather requires the disclosure of impacts on resources, including visual resources. In addition to discussing environmental problems (e.g., impacts on a scenic view) that may be caused by a proposed project, the identification of alternatives and mitigation measures in an EIS presents the means to reduce those impacts. This helps ensure that agency decision making takes into consideration environmental resources and values, in addition to economic and technical factors.

Several federal agencies have developed policies or programs designed to provide a basis for evaluating potential visual impacts from projects and land management decisions, and to provide a framework for managing visual resources to meet specific objectives. The agencies use these systems to establish the baseline visual conditions and to evaluate the potential impacts of projects on the visual setting. Federal agencies that currently have visual resource management or project assessment systems include:

- Bureau of Land Management (BLM—Visual Resource Management (VRM) (BLM 1984)
- U.S. Forest Service (USFS)—Scenery Management System (SMS) (USFS 1996); Visual Management System (VMS) (USFS 1974)
- Federal Highway Administration (FHWA)—Visual Impact Assessment for Highway Projects (FHWA

TIP

In reviewing a VIA, NPS staff should be sure that the analysis includes discussion of potential impacts on historic properties and cultural landscapes. Close coordination with the cultural resource and cultural landscape reviewers will assure compliance with Section 106 requirements.

1988)

- U.S. Army Corps of Engineers (USACE)—Visual Assessment Procedure for U.S. Army Corps of Engineers (Smardon et al. 1988)

The National Historic Preservation Act of 1966 (NHPA) established the protection and preservation of historic and cultural resources as a federal responsibility. Section 106 of the NHPA specifically requires federal agencies to consider the effects of their undertakings on “any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places.” This helps assure that all affected parties are consulted with regard to protection of historic resources prior to federal approval for projects. Many types of properties may be eligible for the *National Register of Historic Places* (NRHP) based on characteristics that could be adversely affected by visual impacts from renewable energy development. The NHPA includes cultural landscapes as resources to be protected through cultural resource management. This means that each and every individual historic property needs to be considered, including the overall landscape. These landscape settings will include aspects of integrity that are identified in their NRHP nomination form that will guide the analysis of potential impacts on the landscape and will provide indicators for potential effects that could affect their listing in the NRHP. In some cases (e.g., historic lighthouses, forts, or battlefields), the visual setting is important to the integrity of NRHP-listed or NHRP-eligible sites.

2.7 Non-Federal Requirements for Visual Impact Assessment

Non-federal agencies may not manage scenic quality, especially at the landscape scale. Management would require development of scenic quality objectives that would typically be based on a detailed inventory and description of the existing visual setting. There are exceptions; in areas such as the Columbia River Gorge and the communities around the Blue Ridge Parkway, local agencies cooperate to maintain the visual character of the areas as the nearby communities continue to grow. This level of identifying visual resource management objectives across the larger landscape is not usually done at the state or local level because management authority does not extend over large areas or onto private lands, or because agencies are focused on other management goals. However, the more local entities are aware of NPS’s interests, they may become sources of information regarding projects and potential effects on NPS resources.

2.8 State Requirements

Several states have environmental analysis requirements similar to NEPA, such as the California Environmental Quality Act, Washington’s State Environmental Policy Act, or Maine’s Wind Energy Act, and they include visual resources as a topic for analysis. Other states may have processes for review of environmental resources, and NPS staff need to know whether the state(s) in which a park or trail is located has any provisions for this analysis. These laws require disclosure of the impacts on the visual landscape and may require mitigation to “less than significant” impact standards. However, there generally are not state-level visual management objectives to guide siting, design, and development of projects on state-owned lands. State-level environmental reviews do have a mechanism for public comment on perceived visual intrusions. This is an opportunity for NPS to voice concerns for the public record, and comments NPS submits will often require an agency response.

2.9 Local Requirements

Local requirements for renewable energy projects to assess visual impacts are rare at this time. Counties and municipalities may have general guidance for community aesthetics or visual character, and these will typically take the form of goals and objectives in their respective comprehensive plans. Local ordinances may provide some restrictions to development for aesthetic purposes; however, these are generally focused on small-scale development and not on landscape-scale viewshed management.

> **TIP**
>
> *Developing relationships with local agencies and other stakeholders may lead to early knowledge of projects that may affect NPS resources.*

2.10 Opportunities for Involvement in the VIA Process

Preparation of a VIA for a project may begin during the pre-application process. This is also the stage at which the scope of analysis is prepared, so early engagement can help ensure NPS concerns are included in the analysis. The VIA may also be initiated during the development of the final POD for the application, and VIA development may extend into the preparation of the Draft EIS because project alternatives will be better defined for the analysis at that time. Throughout the preparation of the VIA, it is critical to maintain contact with the visual resources lead person for the agency. To the extent the agency and proponent will allow it, direct communication with the contractor performing the visual impact analysis can be helpful, as long as the lead agency is kept informed of all communication. Below are key steps for staying involved throughout the development of a VIA.

- Initiating consistent and direct contact to ensure clear communication and exchange of data. It is recommended that NPS staff provide data such as key observation point (KOP) locations, viewshed information, and other geographic information system (GIS) data, as available, in the format required. NPS can also request and receive the results of the visibility analysis and draft project simulations, in order to understand potential impacts early in the planning process.
- Maintaining a presence at all project meetings—and keeping NPS concerns on every agenda—where visual resources will be discussed. This will help NPS staff gain a better understanding of the process, allow for questioning (as needed) the lead agency and contractors about the analysis, and provide the opportunity to voice concerns or support for alternatives to the project team.
- Maintaining a comprehensive project file to document how the analysis proceeded, and how/if the project design and/or alternatives evolved in response to NPS comments.
- Assisting the lead agency and contractor in developing mitigation measures and the criteria/methodology for determining the effectiveness of mitigation. It will be critical not only that the mitigation be as effective as possible, but also that the NPS unit begins to identify any change from an established baseline in the amount of KOP use or the profile of KOP users, at any of the KOPs identified in the planning process.

3. Visual Impact Assessment Overview

This chapter presents an overview of the VIA process and introduces key concepts, processes, and terminology needed to evaluate a VIA.

3.1 Visual Contrasts versus Visual Impacts

Visual impacts are defined as changes to the scenic attributes of the landscape brought about by the introduction of visual contrasts (e.g., development) and the associated changes in the human visual experience of the landscape. Visual impacts can be positive or negative. If viewers feel that the visual contrasts generated by a change to the visible elements of the landscape improve its scenic qualities, the impact is positive. If viewers feel that the contrasts detract from the scenic quality of a landscape, the impacts are negative.

The concepts of **visual contrast** and **visual impact** are central to understanding how VIAs are conducted.

Figure 3.1-1. White Wind Turbines in a Natural-Appearing Landscape (Credit: Argonne National Laboratory)

- *Visual contrast* is change to what is seen by the viewer. For example, if wind turbines are introduced into a natural prairie landscape (as in Figure 3.1-1), the introduction of the tall shapes of the towers, their white color, long vertical lines, smooth textures, moving blades, and flashing lights at night are all visual contrasts that people can see.
- *Visual impact* is both the change to the visual qualities of the landscape resulting from the introduction of visual contrasts—in this case from the building of a renewable energy facility—and the human response to that change. Continuing with the wind energy example above, the introduction of tall, white wind turbines into the prairie landscape may affect the perception of the landscape as a natural-appearing setting dominated by strongly horizontal elements such as the horizon line or distant ridges. Instead, it may be perceived as a landscape strongly influenced by human activities and dominated by the strongly vertical elements of the wind turbine towers and the movement of the turbine blades. These are changes to the visual qualities of the landscape. Some viewers may think that the addition of wind turbines improves the view, perhaps because it adds visual interest and a dynamic quality to an otherwise static scene, or because they strongly support renewable energy and regard the sight of wind turbines as a symbol of progress. For these people, the visual impact of the wind turbines is positive. Other viewers may feel that the wind turbines add visual clutter or interfere with the view of mountains they enjoy, or that the wind power facility introduces an industrial-appearing element into a natural-appearing landscape where they feel it does not belong. For these viewers, the visual impact of the wind turbines is negative. Both viewer

reactions are human responses to the changes in the visual quality of the landscape caused by the introduction of the turbines.

Broadly conceived, the purposes of a VIA for a proposed project are to:

- Describe the existing landscape elements and landscape character for both the region and the project area;
- Identify and describe the nature and extent of visual contrasts caused by the proposed project;
- Determine the resulting changes in the visual qualities and character of the landscape;
- Assess the potential effects of the visual contrasts on the viewer experience;
- Specify impact mitigation measures to avoid, reduce, or compensate for the visual impacts of the project; and
- Determine whether the project is consistent with any visual resource management objectives that may apply.

In practice, for a variety of reasons, a VIA may not always fulfill these purposes. The descriptions of visual contrasts arising from the project and the viewer responses may be inaccurate or incomplete, primarily because of insufficient or incorrect information about the project, likely viewpoints, or viewers; or because of improper impact assessment methods.

3.2 VIA Process Overview

Developing a thorough VIA is a complex multistep process that typically includes the following steps:

- Gathering information and preparing a description about the regional and project landscape setting.
- Reviewing relevant planning and regulatory documents to identify applicable requirements for impact assessment methods and to aid in the determination of the project's compliance with visual resource management goals and objectives of the relevant land management and planning agencies.
- Gathering information about the project and preparing descriptions of the visual characteristics of the project and sources of visual contrast associated with the project.
- Determining the potential visibility of the project from nearby lands through viewshed analysis. The result of the viewshed analysis is the project viewshed map, which shows areas within a specified distance of the project from which the project elements could be seen. The results of the viewshed analysis are used to identify important visual resource areas (including sensitive scenic, historic, cultural, and tribal resources) and other sensitive viewpoints (residential areas, roads, etc.) that would have views of the proposed project.
- Identifying important viewpoints (KOPs) within the project viewshed. The KOPs are locations from which the visual contrasts and visual impacts of the project will be assessed.

- Gathering information about KOP users, that is, persons who would be likely to be viewing the landscape at each KOP, and preparing a description of the users for each KOP. This information is generally directed at determining the likely numbers of viewers at each KOP, the expected duration of views of the project, and the potential sensitivity of the viewers to changes in the landscape as seen from the KOP.
- Preparing spatially accurate and realistic visual simulations (usually photomontages) of the project to inform decision makers and other stakeholders about the likely appearance of the proposed project as seen from the KOPs.
- Evaluating the simulations to assess the nature and extent of visual contrasts the proposed project will introduce into the existing landscape.
- Preparing an impact determination based on judgments about the effects of the predicted visual contrasts on the visual qualities and character of the landscape and the perceptions of viewers likely to see the project. In addition to direct visual impacts from the proposed facility and associated facilities, such as transmission lines and substations, the assessment includes indirect and cumulative visual impacts.
- Recommending impact mitigation actions that would avoid, reduce, or compensate for the anticipated impacts.
- Determining whether the project complies with any applicable visual resource management objectives that apply to the project area and surrounding lands based on the impact determination and identified mitigation.

The following subsections describe these VIA processes and introduce key concepts and terms associated with them.

3.3 Describing the Regional and Landscape Setting

Typically, a POD is submitted for the project which will contain technical documentation that describes the location, layout, and elements of the proposed project. On the basis of the location information in the POD, the first major step in the VIA process is to gather information about the characteristic regional landscape setting and the landscape setting in the vicinity of the project. The information includes a description of the physical environment, such as major landforms, vegetation, water bodies, and climate; discussion of the landscape character, that is, the scenic characteristics and quality of both the regional landscape and the immediate surroundings of the proposed project; and the nature and extent of human presence and modifications in the regional and project settings. Any relevant existing land use, visual resource management, or scenic conservation plans or programs are also described. This important information establishes baseline conditions for assessing visual contrasts and associated visual impacts.

In a NEPA VIA document, this information is synthesized in the *Affected Environment* section (see Section 4.1 of this document for discussion of the *Affected Environment* section of a NEPA VIA for utility-scale wind, solar, and transmission facilities). A more detailed discussion of the regional and project landscape setting description can be found in Section 4.1.2.

3.4 Review of Regulatory and Planning Documents

Depending on the project location, a variety of federal, state, and local laws, ordinances, regulations and standards (LORS), and agency policies concerning visual resource protection and management may apply to utility-scale renewable energy projects. As an early step in the VIA process, the analyst will gather and review applicable LORS and agency policies.

The applicable LORS will be described in the VIA, and they may also dictate that particular methods for visual impact analysis be followed; for example, on BLM-administered lands, the impact assessment methodology must adhere to the requirements of the BLM's VRM system. There may also be a variety of other planning documents that should be reviewed; for example, BLM Resource Management Plans and USFS Forest Plans specify visual resource management objectives for agency-administered lands that are needed for the VIA.

In a NEPA VIA document, applicable LORS and visual resource management plans and requirements are often discussed in the *Affected Environment* section (see Section 4.1), but they may also be discussed in the *Environmental Consequences* section (see Section 4.2). A more detailed discussion of LORS can be found in Section 4.1.2.

3.5 Describing Visual Characteristics and Sources of Visual Contrast

Based primarily on information in the POD, the VIA analyst prepares a narrative description of the visual characteristics of the project. The narrative identifies and describes the sources of visual contrast associated with the project, for example, structures, roads, lighting, vegetation clearing, landform changes, movement, glare, and human and vehicular activity. "Design arts" terminology familiar to landscape architects, such as *form, line, color,* and *texture,* is typically used.

The variability in the appearance of the facility over time and in different weather and lighting conditions is discussed as well; for example, if the facility will look substantially different in winter because of leaf drop, vegetation color change, or the presence of snow, this is noted and described. Night-sky impacts are described as well. The anticipated length of each project phase is also included.

In a NEPA VIA document, the descriptions of the visual characteristics of the project and associated sources of visual contrast are often contained in the *Environmental Consequences* section (see Section 4.2). A more detailed discussion of the visual characteristics of the project and sources of visual contrast can be found in Section 4.2.2.

3.6 Visibility and Viewshed Analysis

A critical early step in the VIA process is to determine the geographic scope of the impact assessment in order to limit the area of detailed investigation. Visual impacts are assessed from lands with views of the project and the associated activities (e.g., project construction). VIA analysts use the term **viewshed** to describe areas visible from a given point or points, and determining the project's viewshed is a key step in the VIA, because it identifies areas from which there may be views of the project. Identifying the viewshed for the project and the associated activities is accomplished primarily through **viewshed analysis**, a spatial analysis that uses elevation and landcover data to determine which parts of the surrounding landscape are likely to be visible from a designated point or points.

The analyst must also determine the distance away from the project that will be the outer limit or geographic extent of the analysis for visual impacts, sometimes referred to as the Study Area, the Zone of Visual Influence, or Area of Potential Effect. The appropriate area varies by project type and location.

The result of the viewshed analysis is the viewshed map, which generally uses color shading to show which areas have views of the project. Unshaded areas are screened by topography, vegetation, or structures, and therefore do not have views of the project. The viewshed map is used to identify sensitive visual resource areas (e.g., national, state, or local parks, historic sites, trails, and cultural landscapes) and other sensitive viewpoints (e.g., residential areas) that would have views of the project and thus may be subject to visual impacts from the project. From these areas, KOPs are selected.

In a NEPA VIA document, the viewshed analysis, the geographic limits of the impact analysis, and the identification of potentially affected sensitive visual resource areas are typically discussed in the *Affected Environment* section (see Section 4.1). More detailed discussion of these topics can be found in Section 4.1.2. Appendix A provides technical details on viewshed analysis.

3.7 Identifying KOPs

After determining the area of analysis and using a viewshed analysis to determine from which areas a proposed project may be visible, these areas are examined for selection of one or more KOPs. KOPs are places from which a proposed project is likely to be seen by people; that is, the places within the viewshed where people are most likely to be located. In a VIA, KOPs are selected as the primary locations from which the visual contrast and impacts of the project will be assessed. For a VIA with KOPs within a NPS unit that encompass a view that extends beyond park boundaries, park resource managers may provide KOP locations based on current knowledge and/or historical information.

Places with a clear connection to scenic resource use, such as scenic overlooks (see Figure 3.7-1), scenic byways, or scenic trails are obvious choices as KOPs; however, any location where people are likely to be found that has a view of the project may be a suitable KOP. The KOPs in a VIA may include such places as nearby communities or housing developments, non-scenic roads, historic sites, recreation sites, wilderness areas, or mountain peaks that may or may not be a concern to NPS. KOPs should include places with the “worst case” (most prominent) view of the project; however, representative KOPs may also be selected.

In a NEPA VIA document, KOPs selected for the impact analysis (and the rationale for their selection) are often discussed in the *Affected Environment* section (see Section 4.1), but they may also be discussed in the *Environmental Consequences* section (see Section 4.2). A detailed discussion of KOP selection can be found in Section 4.1.2.

Figure 3.7-1. Dante's View, a Scenic Overlook, in Death Valley National Park (Credit: Argonne National Laboratory)

3.8 Identifying Viewers and Viewer Sensitivity

On the basis of information gathered from a variety of sources, information about KOP users who would likely see the project is gathered and synthesized. As noted in Section 3.1, visual impact includes the human response to visual contrasts associated with changes in the visible landscape. Understanding the characteristics of persons who would likely view the actual project is important because it is the human response to visible changes in a landscape that determines whether the changes represent an improvement in scenic attractiveness (a positive visual impact) or a decrease in scenic attractiveness (a negative visual impact), as well as determining the magnitude of the impact. To the extent that knowledge about the viewers leads to more accurate assumptions about likely human responses to changes in the visible landscape, a more accurate assessment of potential visual impacts will result. VIAs include the following information about viewers:

- Potential number of viewers,
- Frequency and duration of views of the landscape in which the project would be located,
- Reason viewers are present at viewpoints,
- Activities in which the viewers are engaged while viewing the landscape and the importance of scenic quality to these activities,
- Viewer familiarity with the landscape, and
- Viewer concerns for the landscape.

In a NEPA VIA document, viewer information is typically included in the *Affected Environment* section (see Section 4.1). It may also be found in the *Environmental Consequences* section (see Section 4.2). Detailed discussion of viewer characteristics can be found in Section 4.1.2.

3.9 Preparing Visual Simulations

Visual simulations are spatially accurate and realistic visualizations (typically computer-generated) of the project and surrounding landscape that are used to depict the overall appearance of a proposed project. In typical VIAs, simulations are used to depict views of the project from selected KOPs. Simulations are usually prepared by the impact assessment team or by contractors. Simulations are an important component of VIAs for renewable energy projects, and their primary use is to help the impact analyst assess the visual contrasts created by the project. Simulations also help project stakeholders and decision makers visualize projects and respond to development proposals.

The development of high-quality simulations and their proper use for VIA is a complex technical undertaking. Simulations are subject to errors and inaccuracies that may have important effects on the quality of the finished product. Even the best simulations have important limitations in terms of accuracy and realism. It is important that NPS staff have a basic understanding of the visual simulation development process and the limitations of simulations in order to interpret and evaluate them properly.

In a NEPA VIA document, the methodology used to develop simulations is often discussed in the *Environmental Consequences* section (see Section 4.2). Chapter 5 of the Guide is devoted to a detailed discussion of the use and evaluation of visual simulations in VIAs. Section 5.2 presents best practices for simulation preparation and presentation in VIAs and also discusses the limitations of simulations, sources of errors and inaccuracies in simulations, and tips for spotting issues. These guidelines are also summarized in a Visual Simulation Checklist in Appendix C.

3.10 Identifying Visual Contrasts

In NEPA VIAs, information about the project's visibility, information contained in the project's POD, and the prepared simulations are typically used as the primary basis for judging expected visual contrasts associated with a proposed project. The contrast assessment is the primary basis for the determination of impacts.

The impact analyst will examine the POD to develop a list of contrast sources (e.g., energy collectors, buildings, roads, fences, and lighting) and will generally provide that list as part of the contrast assessment. A thorough VIA will describe the contrasts expected for all project phases based on information in the POD. The description of contrasts should include describing the scenic resource areas that may be affected, including quantifiable measures such as acres within the scenic resource areas (or mileage of trails, roads, or other linear features) that will have views of the project, and the distances involved.

The analyst will then examine the simulations, and after determining their spatial accuracy, realism, and representativeness of the range of contrasts to be expected, will compare the simulations to "before" photographs and develop a narrative that describes the visual contrasts that will be introduced by the facility. Contrasts visible at each KOP are described.

In a NEPA VIA document, visual contrasts from the project are discussed in the *Environmental Consequences* section (see Section 4.2). Section 4.2.2 includes a detailed discussion of how visual contrast is determined, and the visual contrasts associated with wind, solar, and transmission facilities.

3.11 Determination of Impacts

Once the identification and description of contrasts has been completed, it is used as the basis of the impact determination. The impact determination will consider the effects of the contrasts introduced by the project on:

- The visual qualities and character of the landscape within the project viewshed, and
- The visual experience of persons likely to be viewing the project and the surrounding landscape.

> ***TIP***
>
> *NPS staff should review scenic inventories and assessments for projects to ensure they have properly accounted for views of neighboring lands like national parks and other special status areas, where views across BLM, USFS, or other lands are a highly valued part of the visitor experience.*

The description of impacts on the visual qualities and character of the landscape within the project viewshed is typically in the form of a simple descriptive narrative. Changes that affect the project area's scenic qualities and landscape character are described; for example, the introduction of man-made elements into natural-appearing landscapes, or the introduction of industrial elements into a pastoral or agricultural setting. However, the impact determination may incorporate a more formal process when there is a system in place by which scenic qualities are inventoried and assigned to the lands in question. For example, where the project will be located on BLM, USFS, or other lands that have been formally inventoried for scenic values, such lands have been assigned a scenic rating or value, indicating the relative visual values. Impacts will then also be discussed in terms of potential changes to inventoried scenic values. Generally, the impacts will only be assessed on the lands managed by the agency with respect to its inventoried values. A VIA may not account for neighboring lands, like national parks or special status areas, where views across lands where potential impacts may occur are an important part of the visitor experience.

Determining impacts on potential viewers involves consideration of the number of viewers, the types of viewers and their potential sensitivity to changes in the visible landscape that would occur if a proposed project is built, and the likely duration of their views of the project. Sensitivity to changes in the viewed landscape is related to the viewers' attitudes, individual preferences, the activities in which they are engaged while viewing the site, and their expectations for scenic quality in the lands they view. On the basis of these considerations, the analyst predicts the effect of the changes in the visible landscape on the viewers' visual experience for all KOPs included in the analysis, and for other areas within the project viewshed.

In a NEPA VIA document, visual impacts of the project are discussed in the *Environmental Consequences* section (see Section 4.2). Section 4.2.2 discusses determination of direct visual impacts of a proposed project. EISs must include alternatives to the proposed action. Section 4.2.2 also discusses determination of visual impacts of alternatives that are typically considered for wind, solar, and transmission projects.

In addition to visual impacts directly associated with the construction, operation, and decommissioning of the facility, the overall impact finding also includes the indirect and cumulative visual impacts of the facility. Indirect impacts are defined in various ways but usually refer to impacts that occur away from the project, either in a spatial or a temporal sense, or both. Cumulative visual impacts are the combined effects from the proposed project with other past, present, and likely future projects or activities, whether of the same type or not, within a certain prescribed distance from the proposed project. Indirect visual impacts and cumulative visual impacts are discussed in Section 4.2.2.

3.11.1 Mitigation

Under NEPA, EISs must include mitigation; that is, measures that could be undertaken to avoid, reduce, or compensate for the potential impacts of the proposed action. Visual impact mitigation for energy facilities includes a range of activities, including project siting and design measures, choices in structural materials and coatings that reduce the visibility of project components, vegetation and soils management practices that preserve the more natural-appearing backdrop of facility sites, lighting controls, and various other practices. Mitigation is specified for each phase of facility development, including site assessment, construction, operations, and decommissioning.

Section 4.2.11 briefly summarizes the different types of mitigation measures that may be used for utility-scale wind and solar facilities, and electric transmission facilities. Appendix C includes a comprehensive checklist of visual impact mitigation measures that may be used for mitigation of visual impacts associated with renewable energy facilities and associated project elements such as transmission lines, roads, and structures.

In a NEPA VIA document, potential or required mitigation measures are often contained in the *Environmental Consequences* section (see Section 4.2), though they may be presented as part of the analysis of alternatives or included as a separate section.

3.11.2 Compliance with LORS and Visual Resource Management Objectives

Considering both the identified visual impacts of the proposed project and any mitigation actions that will be required, the analysts will determine whether the project—with the required mitigation—will be in compliance with the applicable LORS and agency visual resource management objectives. The analyst will then systematically document compliance/non-compliance with LORS and agency management objectives.

In a NEPA VIA document, applicable LORS and agency visual resource management objectives and impact assessment methodologies are often contained in the *Affected Environment* section (see Section 4.1). Compliance with LORS and agency management objectives is usually discussed in the *Environmental Consequences* section (see Section 4.2). A more detailed discussion of LORS compliance can be found in Section 4.2.4.

4. Elements of Visual Impact Assessments

The focus of this chapter is on evaluating a VIA prepared for an offshore/onshore wind, solar, or transmission project near a NPS unit. The discussion focuses on critical elements of the analysis, information that should be included in the assessment, common weaknesses in impact assessments, and tips for identifying and addressing these weaknesses. Special attention is given to assessment of visual contrasts, with emphasis on contrasts associated with onshore and offshore wind, solar, and electric transmission projects.

4.1 Affected Environment

The *Affected Environment* section of an EIS provides baseline information for the impact analysis by describing the existing environment that may be impacted by actions under the alternatives and by describing particular resources and receptors that may be affected.

4.1.1 Overview of the Affected Environment Section

A thorough *Affected Environment* section of a VIA provides a wealth of critical information needed to accurately assess the visual impacts of a proposed project:

- It usually identifies any applicable visual resource-related **laws, ordinances, regulations, and standards** (LORS) with which the project must be in conformance.
- It provides critical information about the **regional and project visual settings** necessary to understand how well the proposed facility would “fit in” with both its immediate surroundings and the broader landscape setting and land uses.
- It identifies the **area of impact analysis;** that is, the distance from the project within which impacts will be assessed, necessary to understand the spatial extent of non-negligible impacts.
- It provides information about the **potential visibility** of the project from surrounding lands/waters, information needed to determine the area theoretically subject to visual impacts.
- It identifies specific **valued visual resources** that may be affected by actions under the alternatives, including scenic, historic, cultural, and tribal resources.
- It identifies and describes **KOPs** within the viewshed of the proposed project that will be used in the impact analysis and provides a rationale for their selection.
- It describes **potential viewers** of the proposed project and their sensitivities.

4.1.2 Affected Environment: Content

The following sections describe key content that is normally included in the *Affected Environment* section of a NEPA VIA.[3]

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[3] Environmental impact assessment documents vary in depth and breadth, organization and layout, writing style, and naming conventions. Some topics discussed in this section may not be in the *Affected Environment* section of an

Applicable Laws, Ordinances, Regulations, and Standards, and Agency Policies

A variety of federal, state, and local LORS concerning visual resource protection and management may apply to utility-scale renewable energy projects, depending on land ownership and administration, and legal jurisdiction. For example, the Federal Lands Policy and Management Act of 1976 requires that public lands (i.e., BLM-administered lands) be managed to protect scenic values and requires that DOI inventory scenic values on public lands. States and counties may have scenic highway programs. Counties may have open space or night-sky protection ordinances.

> **TIP**
>
> *NPS staff should be knowledgeable about applicable LORS that would apply to projects on nearby lands and discuss potential conflicts with the appropriate parties. While not regulatory in nature on non-NPS lands, the NPS Organic Act is relevant to planning activities beyond park boundaries and should be discussed with adjacent land managers to assure impacts on park resources are considered.*

All applicable LORS should be listed and described in the *Affected Environment* section or elsewhere in the EIS or VIA; sometimes LORS may be discussed in the *Environmental Consequences* section. LORS descriptions should address those portions of the LORS that are relevant to visual resources and would apply to the proposed project.

> **TIP**
>
> *Staff at NPS units with renewable energy or transmission projects on nearby lands administered by agencies with visual resource management programs should become familiar with the basics of these programs because they should be used for the impact analysis. Understanding how the programs work is key to understanding how impacts are determined, but the programs are sometimes misapplied in VIAs.*

In addition to LORS, agencies that manage non-private lands may have policies and programs for visual resource management that require or recommend certain procedures be used to inventory and manage visual resources on agency-administered lands. These policies and programs may also specify mandatory methods for conducting visual impact analyses on agency-managed lands. BLM's VRM Program and the USFS's SMS are examples of agency policy-driven programs for visual resource management with *mandatory* requirements for conducting VIAs. The FHWA's method described in *Visual Impact Assessment for Highway Projects* (FHWA 1981) is a *recommended* approach, as is the USACE's *Visual Resources Assessment Procedure for U.S. Army Corps of Engineers* (Smardon et al. 1988). If a project is located on lands managed by an agency with a program or policy for visual resource management, that fact should be noted in the *Affected Environment* section, and the managing

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assessment, and some assessment documents may not refer to the *Affected Environment* topic area by that name. However, all of the topics described in this section would normally be included in an environmental impact assessment for a major energy facility. Readers may have to look closely at other sections of the environmental impact assessment to see if topics that appear to be missing are addressed elsewhere.

agency's specified impact analysis method must then be used for the impact assessment. If the project crosses lands managed by multiple agencies (common for transmission projects), each agency's impact assessment method must be used for that portion of the project that crosses that agency's lands. For example, for a proposed transmission line across both BLM and USFS lands, the BLM's Visual Contrast Rating method (BLM 1986) must be used to assess impacts for the portion of the transmission line crossing BLM-administered lands, and the USFS SMS approach must be used for the portion of the transmission line crossing USFS-administered lands.

Regional Setting Description

The *Affected Environment* section should include a description of the regional landscape setting. The breadth and depth of the description will vary, but it should include:

- A description of the physical environment, such as major landforms, water bodies, vegetation, and climate;
- Major land uses, such as agriculture, energy development, or recreation;
- The nature and extent of human presence (e.g., mostly natural, rural, or urbanized);
- The extent of existing development that may affect scenic values; and
- Any relevant existing land use, visual management or scenic conservation plans or programs, and those aspects of the plans or programs relevant to the proposed project.

Ecoregions are large units of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions. Ecoregion maps and descriptions are available for the United States. Bailey's or Omernik's ecoregions and Fenneman's physiography are often used as a source of information for much of the regional landscape description, and if so, the appropriate ecoregion map should be included (Bailey 1995; Omernik 1987; Fenneman 1917, 1931, 1938).

Throughout the regional setting description, the emphasis should be on visual components, such as the visual character and scenic qualities of the setting, and other information relevant to visual resources. Rare or endangered landscape/seascape settings in the region should be identified and described. If important viewpoints have been determined as part of a visual management plan, they should be identified and mapped. If the region is known for its scenic, historic, cultural, recreational, night sky, or other resources that have important visual components, that should be noted, and any available information about the number and type of viewers and their sensitivities should be provided.

Photographs should be included to illustrate the visual character of the region. Maps should be used to show key regional features and the location of the proposed project within the region.

Site and Project Setting Description

The *Affected Environment* section should include a detailed description of the physical environment in which the project is sited, the project's landscape setting, and the visual character of the project area and its scenic quality. Any important scenic resources within the project viewshed, and any important viewpoints such as scenic overlooks, historic sites or trails, or sacred sites, should be identified and described. Any cultural disturbances, such as existing development, transmission lines, pipelines, roads, mines, or other modifications, should be identified and described.

The description of the project site should also include:

- Text and one or more maps showing where the project is located; the project's viewshed; the footprint and dimensions of the major project elements; and nearby features of importance, such as major landforms, water bodies, roads, and towns;
- A description of the physical environment, for example, "the project is located in a wide, flat valley, surrounded by low mountains" and discussion of landcover, vegetation types, water bodies, and major infrastructure such as urban areas, transmission lines, and roads; and
- Annotated photographs of the project site, typical vegetation, and prominent landscape features, keyed to a location map.

The discussion of visual character and scenic quality should describe the project setting in terms of the basic design elements of form, line, color, and texture. For projects on non-private lands administered by agencies with visual resource management programs or recommended practices, the appropriate scenic quality inventory units and descriptors should be employed. For example, for projects on BLM lands, Visual Resource Inventory (VRI) values and maps should be presented and discussed, and the landscape's scenic qualities should be discussed in terms appropriate to BLM's VRM system, such as scenic quality ratings, distance zones, and visual sensitivity (BLM 1986b). For projects on USFS lands, scenic classes, user concern levels, and scenic integrity information and maps should be presented and discussed, and the landscape's visual qualities should be discussed in terms appropriate to the USFS's SMS (USFS 1996).

TIP

Other visual inventory systems may not adequately describe the visual character and scenic values of NPS units or other specially designated areas within the viewshed of the project. NPS staff should proactively request that NPS units and areas of concern outside of units that have high scenic value be included and described in the Affected Environment section. Where possible, the project area should be visited in order to assess firsthand the accuracy and completeness of the project setting description.

Any known scenic resource areas and sensitive viewpoints within the viewshed should be identified and described. These points are typically used as KOPs in the impact analysis (see below). Scenic resources would include, but are not limited to, national, state, or local parks, seashores, and monuments, historic and scenic trails and byways, historic and scenic sites, sensitive tribal sites or landscapes, and wildlife refuges. Sensitive viewpoints, such as residential areas and scenic viewpoints or stretches on roads, should also be identified and described. Scenic resources and sensitive viewpoints should be located on maps, preferably overlaid onto the viewshed map(s). The nature of the scenic attributes for scenic resources should be provided, along with information describing the amount of land within the scenic resource area that has potential views of the project site and the particular portions of the resource areas with potential views of the project, with distance zones marked to indicate distances from these areas to the project site.

Area of Impact Analysis

The *Affected Environment* section should identify the geographical limits of the impact analysis, sometimes referred to as the "area of analysis," "zone of visual influence," or simply the "study area." This is the area of detailed impact analysis, beyond which any visual impacts would be negligible or not analyzed at all.

At some distance, the project components may technically be visible, but because of the distance and other factors (referred to as visibility factors), such as lighting and air quality, they may be so small or faint that they are not actually seen by viewers and cause negligible or no visual contrast, and therefore have no visual impacts. The area of analysis is therefore generally smaller than the maximum distance at which the facilities could be seen under ideal conditions. Appendix B provides a detailed discussion of visibility factors and their importance for visual impact analysis.

The determination of the area of analysis is important because if the distance is too short, potential visual contrasts may be excluded from the analysis; if it is too long, limited resources are wasted on the analysis without producing useful information. Unfortunately, there is no "one size fits all" area of analysis, and there are no commonly accepted standards. The appropriate area of analysis varies by project type, region of the country, and landscape setting. Because of their unusually large size and/or height, and because of their high reflectivity, wind and solar projects typically should have larger areas of analysis than other proposed developments, such as oil and gas developments. Research conducted for the BLM has shown that solar and wind projects can be visible beyond 30 mi in some landscape settings in the western United States (Sullivan et al. 2012a,b).

Research conducted for BOEM has shown that offshore wind turbines can also be visible well in excess of 20 statute miles (Sullivan et al. 2013a). Research conducted for the BLM has shown that lattice transmission towers can be visible for more than 10 mi. Cleared ROWs for transmission lines may be visible for much longer distances (Jones and Jones 1976).

The land-based studies cited above were conducted in western landscapes, which typically have cleaner air and more open landscapes than other regions in the United States. Appropriate areas of impact analysis in the central and eastern portion of the country likely are smaller than those required for the western United States; however, research to support areas of analysis specific to these regions is lacking.

TIP

In some VIAs, the areas of impact analysis are too small, resulting in an understatement of impacts, and the rationale presented for choosing the area is missing or inadequate. NPS staff may need to request larger areas of analysis in some cases, particularly for especially sensitive areas, and should always request that the VIA justify the rationale for the selected area of analysis.

The studies cited above also showed that lights used at both solar and onshore and offshore wind facilities can be visible at long distances, in some cases as far, or farther, than the facilities could be seen in daylight (Sullivan et al. 2012a,b; Sullivan et al. 2013a).

The area of analysis is usually described as a radius in miles or kilometers around the project boundary. The distance should be specified in the *Affected Environment* section, and the rationale for choosing the specified area should be included.

Visibility Analysis

The visibility analysis identifies lands surrounding the proposed project location from which the project may potentially be visible. The visibility analysis is a critical part of the VIA because it identifies areas subject to direct visual impacts from the project. The primary tool for determining potential visibility of the proposed project is the viewshed analysis, a GIS spatial analysis that uses elevation data (and sometimes landcover data) to determine which parts of the surrounding landscape are theoretically visible from a designated point or points. A detailed discussion of viewshed analysis is provided in Appendix A.

Most commonly, the elevation data used in the viewshed analysis is in the form of a Digital Elevation Model (DEM) that includes only the land surface and does not include trees, buildings, or other structures that could screen views of the project. Vegetation heights may be estimated from landcover data, or a Surface Elevation Model (SEM) may be used. A SEM does account for tree height and other screening elements in determining elevation.

In the VIA, the results of the viewshed analysis used for the visual impact analysis should be described and presented as one or more maps. The maps should include the project location, KOPs used for the visual impact analysis, and important landscape features, and they should be shaded relief maps so that potentially screening topography is visible. Contour lines are helpful, as are distance zones (e.g., lines placed at regular intervals from the project boundary, such as increments of 5 mi). An example viewshed map is shown in Figure 4.1-1.

> **TIP**
>
> *Viewsheds in VIAs may not account for the screening effects of vegetation, and therefore show what is sometimes referred to as the Zone of Theoretical Visibility. In forested landscapes, Zones of Theoretical Visibility may drastically overestimate project visibility.*

The methodology for the viewshed analysis should be presented, either in the *Affected Environment* section or elsewhere.[4] The methodology presentation should include:

- The elevation data and landcover sources, resolution, and accuracy;
- The software and software modules used to run the analysis;

[4] The viewshed analysis methodology may sometimes instead be presented in a Methodology Appendix or other section in the VIA or EIS describing methodologies used for analyses.

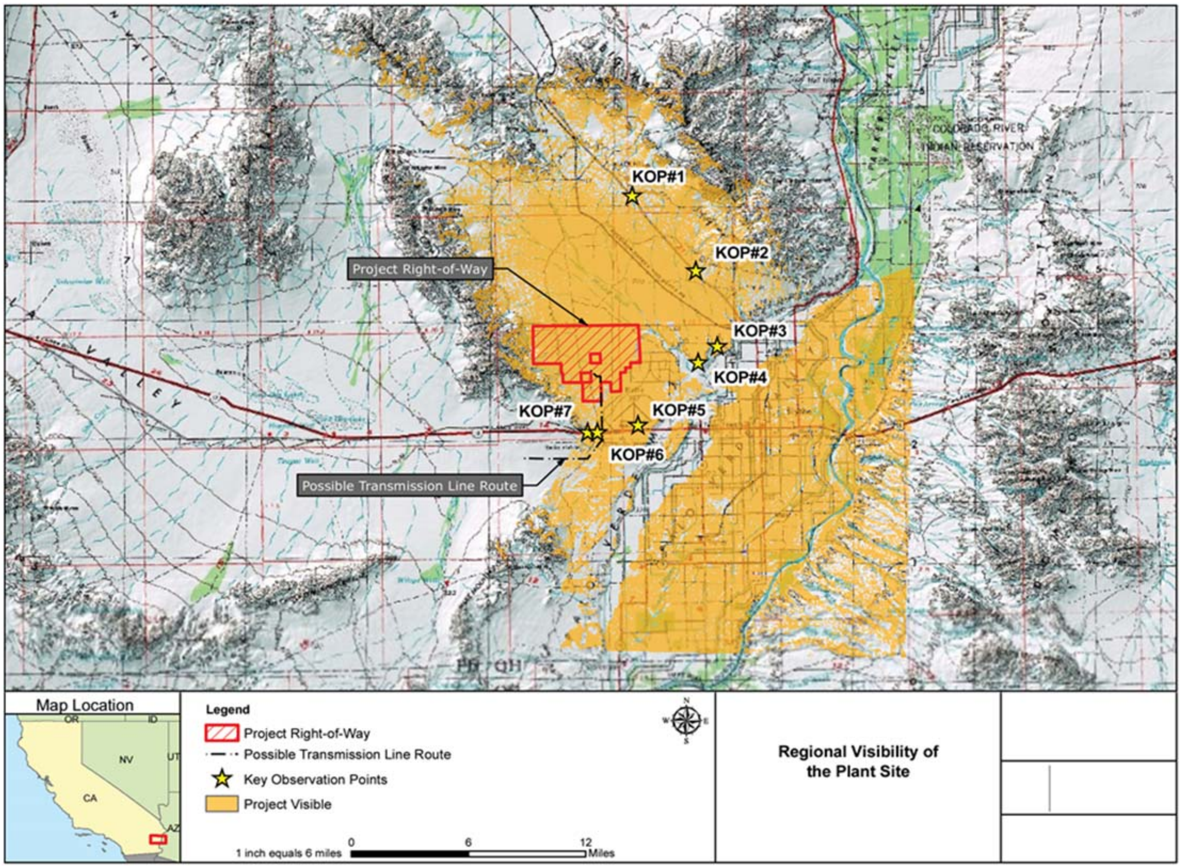

Figure 4.1-1. Viewshed Map for a Proposed Solar Facility (Credit: California Energy Commission)

- The spatial limits of the analysis, for example, all areas within 25 mi of the project;
- How the viewshed origin was determined, for example, if it is a point at the center of the project, a grid of points at regularly spaced intervals across the project, or some other point or points;
- Whether or not the viewshed analysis accounted for vegetation or structures that might screen views;
- The viewer and target height and whether the viewshed analysis shows where partial views of structures would occur or is limited to full views (i.e., does the viewshed show those areas where only the tops of wind turbines or solar facility elements would be visible but the lower portions would be screened by topography or other elements, or does it show only those areas where the entire structure would be visible);

> ***TIP***
>
> *At the long distances at which solar and both onshore and offshore wind facilities may be visible, earth curvature can significantly reduce the visibility of tall structures, and viewshed analyses must therefore incorporate earth curvature to obtain accurate results. Atmospheric refraction may slightly increase the visibility of distant objects; however, the effect is very small and highly variable.*

- Whether or not the analysis accounts for earth curvature (it should) and atmospheric refraction (sometimes omitted); and

- Whether the accuracy of the viewshed analysis was field-checked (it should be verified with accompanying photography, at least from KOPs).

Selecting KOPs

The *Affected Environment* section should identify and describe all KOPs to be used in the visual impact analysis. For each KOP, the description should include:

- A KOP identification number;
- Whether the KOP is a single point, for example, a scenic overlook, or part of a linear feature (e.g., a scenic byway);
- A location description (including global positioning system [GPS] coordinates and elevation);
- The KOP elevation with respect to the project, that is, elevated with respect to the project and looking down at it; level with the project; or below the project looking up at it;
- The distance from the KOP to a specified point in the project (e.g., the center of the project site or the site boundary);
- The rationale for including the KOP in the analysis; and
- A discussion of potential viewers that would be expected at the KOP (see below).

The KOPs should be mapped at a scale sufficient to clearly show their relationship to the project site and to landscape features around the KOPs.

Selection of appropriate KOPs is critical to an accurate assessment of visual impacts because the bulk of the VIA is composed of descriptions of the visual contrasts of the project likely to be observed by viewers at each KOP, and the potential effects of the contrasts on the viewers at the KOPs. These descriptions form the basis for the impact assessment. If too few KOPs are chosen or they are poorly located, impacts on important viewpoints and viewers may be overlooked. If too many KOPs are chosen (i.e., unimportant locations or locations showing essentially the same view), valuable time and effort may be wasted on analyses that do not add significant value.

In some settings, particularly in undeveloped areas with dispersed recreation such as wilderness areas, a lack of roads, trails, or other specific locations where visitors congregate may make selection of KOPs difficult. In these cases, a KOP may be specified that is representative of a larger area, or two or more KOPs could be specified to show the range of potential contrast that might be observed (McCarty 2012).

In general, where multiple KOPs are available, KOP selections should include "worst-case" views, that is, views with the greatest visual exposure to the project, so that important impacts are not omitted from the analysis.

TIP

It is critical for NPS staff to identify and prioritize KOPs in NPS units that may have views of a project outside a park boundary as early as possible, and to bring these KOPs to the attention of the visual impact analyst so that they may be included in the analysis. Requested KOPs should be limited to those truly necessary to gain an understanding of the potential impacts of the proposed project.

Representative KOPs may also be selected. Representative KOPs are locations used for the impact analysis because the impacts at these locations are representative of other locations where the impacts would be expected to be very similar. The use of representative KOPs eliminates the effort and expense of analyzing multiple KOPS where the impact analysis results would be essentially the same. KOPs are commonly points but may also be linear (e.g., roads, trails, or sections of rivers).

Viewer Information

As noted in Chapter 3, information about viewers is critical to accurate impact assessment. Understanding the characteristics of viewers is important because viewer response to the visual contrasts created by the project determines the nature and magnitude of the visual impact. Viewer information that should be included in the VIA falls into five broad categories:

TIP

VIAs often provide minimal information about KOP viewers and sensitivities. In many cases the information is not available. In other cases, insufficient effort is made to obtain the information, or it is deemed unimportant. For resources and viewpoints of concern to NPS, NPS staff should make every effort to supply this information to VIA preparers and to ensure that it is properly used in the impact assessment.

- **Knowledge about the likely number of viewers.** In general, an assumption of most commonly applied visual impact methodologies is that if other factors are held constant, the magnitude of the impact is directly proportional to the number of viewers; that is, for a given project viewed from a given location, if there are more viewers, there would be greater impacts, and if there are fewer viewers there would lower impacts. Seasonal variability in viewer numbers should be noted.
- **Knowledge about the likely frequency and duration of views.** In general, an assumption of most visual impact methodologies is that if other factors are held constant, the magnitude of the impact is directly proportional to the frequency and duration of views of the impacted landscape; that is, longer or more frequent viewing is associated with greater impacts, and shorter or less frequent viewing is associated with lower impacts.
- **Knowledge about the viewers' familiarity with the landscape in which the proposed facility is located.** Most methodologies recognize that persons who live in or near the project area or are regular visitors may be more sensitive to changes in the visible landscape than persons who are unfamiliar with the landscape, such as tourists.
- **Knowledge about the activities in which the viewers are engaged while viewing the landscape in which the proposed facility is located.** Most methodologies assume that certain activities involve more active viewing of the landscape, or may lead to higher expectations of visual attractiveness, which could lead to greater sensitivity to changes in the visual landscape. For example, persons who are visiting a scenic overlook specifically to enjoy the view may spend more time looking closely at the landscape and may also be more sensitive to changes in the visible landscape than persons engaged in an active recreational activity, such as playing volleyball at a day-use area.
- **Knowledge about viewer concern for the landscape in which the proposed facility is located.** While the extent to which viewers would potentially be concerned about visible changes to the

landscape in which the proposed facility is located can be inferred to a degree from the information discussed in items 1 through 4 above, it is important to be aware of any specific and direct statements of concern for the project area from visitors, interest groups, and other stakeholders. Stakeholder forums, government-to-government consultations, and user surveys are useful tools for identifying user concern levels.

In the VIA, for each KOP, potential viewers and their sensitivities should be described, to the extent such information is available. The number of viewers per year should be specified, and the types of viewers (e.g., hunters, hikers, and birdwatchers) should be identified, along with seasonality of use. The degree of potential visual sensitivity of the viewer group should be discussed as well. For example, a historic re-enactment of pioneer travel on the Oregon Trail would likely involve some viewers who would be highly sensitive to changes to the visible landscape, while commuters on a fast-moving major highway would, on average, be less sensitive to changes in the visual landscape.

> **TIP**
>
> *Because of its focus on visitor experiences, the NPS may be able to provide good information about viewers at KOPs within NPS units. It is important to provide such information for use in the assessment if at all possible, because if NPS can demonstrate a high level of concern on the part of viewers, it can make a good case that impacts on the view are important. In addition to visitor surveys and staff knowledge, potential sources of information include NPS unit management plans that may discuss KOP usage and its importance to the visitor experience, and non-NPS publications such as hiking or mountaineering guides that may provide information about recreational users and activities that take place at KOPs.*

Of course, individuals differ in their responses to visual contrasts. These differences arise from a variety of complex and often interacting factors, including life experiences, expectations, and individual aesthetic values. However, while VIAs may recognize these differences, the assessment typically will assume more or less consistency in response among viewers.

> **TIP**
>
> *While impacts from proposed projects generally increase as the number of viewers increases, this does not mean that a low number of potential viewers necessarily will result in low visual impacts. Some landscape settings may have few potential viewers but still be subject to large visual impacts from a proposed project because the viewers may be highly sensitive to human modifications. For example, many wilderness areas have few visitors, but wilderness area visitors are generally seeking views of land retaining natural character, without visible human-made elements. These viewers may be particularly subject to visual impacts from energy and other facilities visible from the wilderness area.*

Intercept surveys are increasingly being used to gather information directly from viewers about the extent, nature, and duration of their use of an area, as well as their expectations for scenic experiences and likelihood to return to the area after a proposed project is built. Surveys may involve asking respondents to rate the existing view and a visual simulation of the view with the proposed project in place. Questions are typically asked about how views of the proposed project would affect users' recreational experience at the viewpoint and whether the users would return to the area if the project is built. Such surveys are subject to sampling and other errors, but in many cases they will provide more accurate information about viewer attitudes and concern levels than other methods. The NPS should encourage their use.

While the information listed above is important to a thorough understanding of the viewers and the their concerns and sensitivities, in many situations detailed information about the numbers, types, and activities of viewers at each KOP may be unavailable, and more general assumptions must be made. If detailed information about viewers is unavailable, the VIA should still discuss viewer characteristics and use the best available information as the basis for assumptions about viewers and estimates of their numbers. When reviewing VIAs, the accuracy of assumptions about viewers must be considered.

4.2 Environmental Consequences

The *Environmental Consequences* section of the VIA is the heart of the analysis; it includes a description of the visual characteristics of the project and the activities associated with the project that may potentially cause visual impacts. It also identifies and describes the potential visual contrasts and associated visual impacts of the proposed action (in this case siting, building, operating, and decommissioning a renewable energy project) and any alternatives to the proposed action under consideration.

4.2.1 Overview of the Environmental Consequences Section

The *Environmental Consequences* section of a NEPA VIA provides information related to the determination of visual contrasts, impacts, and mitigation of a proposed project:

- It describes the **scope and methodology** used for the visual impact analysis;
- For each alternative, it provides a detailed description of the **visual characteristics** of the project and associated **impacting activities**, typically presented by project phase;
- It presents **visual simulations** for the proposed project and alternatives;
- For each alternative, it provides a description of the **visual contrasts** created by the project components and associated activities as evident in the simulations, and as concluded by the analyst for areas not included in the simulations;
- It describes the **direct visual impacts** resulting from the project and alternatives, including changes in the visual qualities and character of the affected landscape and the effects on potential viewers;
- It describes **indirect visual impacts** from the project and alternatives;
- It describes **cumulative visual impacts** from the project and alternatives;
- It describes any **irreversible or irretrievable commitments of visual resources** which would occur if the project were implemented;
- It specifies **mitigation measures** to avoid or reduce visual impacts associated with the project;
- It discusses the project’s compliance with applicable **LORS and agency visual resource management objectives**.

The following sections describe key content that is normally included in the *Environmental Consequences* section of a NEPA VIA.[5]

4.2.2 Scope, Methodology, and Project Visual Characteristics

<u>Scope and Methodology for Impact Analysis</u>

The scope of the impact analysis and the methods employed for the analysis should be discussed, although this information often may be presented in another part of the VIA or EIS. For example, methodology is often presented in a separate section or an appendix. The discussion should address how impacts were determined and should define the impact descriptors (e.g., minor, moderate, and major) used to assign impact levels. If the analysis uses a particular agency's VIA procedure, for example, the BLM Visual Contrast Rating analysis (BLM 1986a), the system should be summarized, and any deviations from the agency's approach should be defined and adequately justified.

> **TIP**
>
> *VIAs for projects on lands managed by federal or state agencies may be required to use a particular methodology for visual impact analysis. In practice, the systems are not always properly applied. NPS staff should examine the methodology used to be sure that it adheres to applicable agency requirements.*

<u>Visual Characteristics of a Project and Sources of Visual Contrast</u>

The VIA should include a thorough description of the project's visual appearance. The description should contain all visible construction and operation components, including ancillary facilities such as equipment laydown areas, transmission facilities, substations, roads, ponds, pipelines, communication towers, and similar elements that may not ordinarily be thought of as part of the project. The description should address all facility elements likely to cause non-negligible visual impacts and should describe impact sources in terms of their general appearance, approximate dimensions, surface colors, and textures. Pictures and/or diagrams of the project site and facility layout as well as individual key components (e.g., wind turbines, maintenance buildings, solar collectors, cooling towers, and transmission towers) should be included or referred to if they are located elsewhere in the EIS. The VIA should also discuss how visual concerns were addressed in the project siting and design process, noting any actions taken to reduce potential impacts.

For each impact source, the description should note the mechanisms by which visual contrasts and impacts may be created (e.g., form, line, texture, and/or color contrast) and should note the potential for reflections (glint or glare), luminosity (from lighting), or other visual effects, including movement

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[5] Environmental impact assessment documents vary in depth and breadth, organization and layout, writing style, and naming conventions. Some topics discussed in this section may not be in the *Environmental Consequences* section of an assessment, and some assessments may not refer to the *Environmental Consequences* topic area by that name. However, all of the topics described in this section would normally be included in an environmental impact assessment for a major energy facility. Readers may have to look closely at other sections of the environmental impact assessment to see if topics that appear to be missing are addressed elsewhere.

of components, water vapor and smoke plumes, and dust. Because visual contrast sources from utility-scale energy facilities are substantially different during different project phases, the description should address all major project phases, typically site characterization, construction, operation, and decommissioning.

Activities associated with the facility should also be described and should include the presence of workers, vehicles, and other equipment, both in daytime and nighttime settings. Though temporary, in some situations, visual contrasts from facility construction and decommissioning activities may be much greater than those during facility operation, and it is important that they be covered in the VIA. This situation may change as more facilities are constructed and the actual impacts from operations and maintenance are understood. Discussion of impacting activities should also include site testing and evaluation, as well as operations and maintenance activities.

TIP

NPS staff should consult periodically with the developer or land management agency to monitor changes to the project design to ensure that NPS always has a clear understanding of the likely appearance of the "as-built" project as the design evolves over time.

A common problem with VIAs is that they are prepared using information from a POD that is developed early in the siting and design process, when important aspects of the facility design may not have been finalized. It is not uncommon for there to be changes in choice of wind turbine type and number, solar collector array size and layout, transmission structure type, or changes to materials and surface treatments after the POD and VIA are prepared, sometimes as a result of stakeholder input. Consequently, the VIA may be missing important information or may describe the location or appearance of facility components inaccurately.

Presentation of Visual Simulations

Visual simulations are typically the primary basis for determining the visual contrasts associated with renewable energy facilities in VIAs, though they should not be the only basis for contrast assessment. In typical VIAs, simulations are presented either in the *Environmental Consequences* section of the EIS, in a separate appendix, or even in a separate volume, in part because the simulations may be presented in large page formats.

Chapter 5 is devoted to a detailed discussion of the use and evaluation of visual simulations in VIAs. Section 5.2 presents best practices for simulation preparation and presentation in VIAs and also discusses the limitations of simulations, sources of errors and inaccuracies in simulations, and tips for spotting issues. These guidelines are also summarized in a Visual Simulation Checklist in Appendix C.

4.2.3 Description of Visual Contrasts

Typically, the description of contrasts will center on the simulations; that is, there will be a narrative prepared for each simulation. Contrasts are normally described in terms of changes to *form, line, and color,* and *texture, scale, dominance, intactness, harmony,* or other descriptors, and will compare those characteristics for the project area before and after implementation of the project, describing the important differences between the "before" and "after" characteristics. The magnitude of the potential contrasts expected is often included, that is, "weak contrasts," "strong contrasts," etc.

The VIA should include a detailed discussion of the expected visual contrasts resulting from the proposed facility and associated activities (e.g., construction or decommissioning activities) as they would be observed from each of the KOPs, regardless of whether they are KOPs for which simulations are presented in the VIA. The discussion should include a general description of the appearance of the facility and associated activities. It should also describe the contrasts in terms of the design elements of form, line, color, and texture, or similar descriptive terms. Figure 4.2-1 illustrates how the introduction of a solar facility to a desert landscape creates contrasts in form, line, color, and texture with the existing landscape.

> **TIP**
>
> *While some methodologies may not explicitly include the consideration of visual impacts from nearby protected areas, like national parks and trails, a VIA that is done correctly will include the impacts on the overall landscape. If it does not, request that they be included.*

For projects on lands/waters administered by an agency with an established VIA procedure, the assessment methodology and terminology employed should be consistent with that agency's procedure, and, in fact, this may be required by the agency. For example, the BLM requires that VIAs for projects proposed on BLM-administered lands use its Visual Contrast Rating System (BLM 1986a) to identify and describe visual contrasts, which involves comparing the forms, lines, colors, and textures of the landform/water, vegetation, and structures of the existing landscape with those that will be visible after the project is built, or more precisely, during all phases of the proposed project, including construction and decommissioning. If a project is located on lands administered by multiple agencies (common for transmission projects), each agency's impact assessment method must be used for that portion of the project land administered by the agency. If a project includes private lands, NEPA requires that the impacts must still be disclosed; however, there will not be an agency-prescribed method required for the analysis of impacts on private lands. In some cases, for consistency's sake, the impact analyst may choose to use an agency method (e.g., the BLM's VRM system) to assess contrasts; however since it is private land, the portion of the method that assesses compliance with agency policy or visual resource management objectives will be ignored. In other cases, the analyst may use a different method to assess contrasts.

The magnitude of visual contrasts is usually described as "weak," "moderate," or "strong," and may also include "negligible." Regardless of the scale used, the terms should be defined and differentiated, but it must be recognized that it is difficult to be precise in judging fine differences among multiple imprecisely defined visual factors. Again, for projects on lands administered by an agency with an established VIA procedure, the system may specify the terms to be used to describe contrast magnitude.

VIAs typically use visual simulations as the basis for identifying and describing visual contrasts associated with proposed projects, pairing a photograph of the existing landscape with a simulation showing the landscape with the proposed facility during the operations phase; that is, after the project has been constructed and operations and maintenance are the main activities taking place.

Simulations have important limitations for use in contrast assessment and are subject to error. These topics are covered in detail in Sections 5.5 and 5.6 of the Guide.

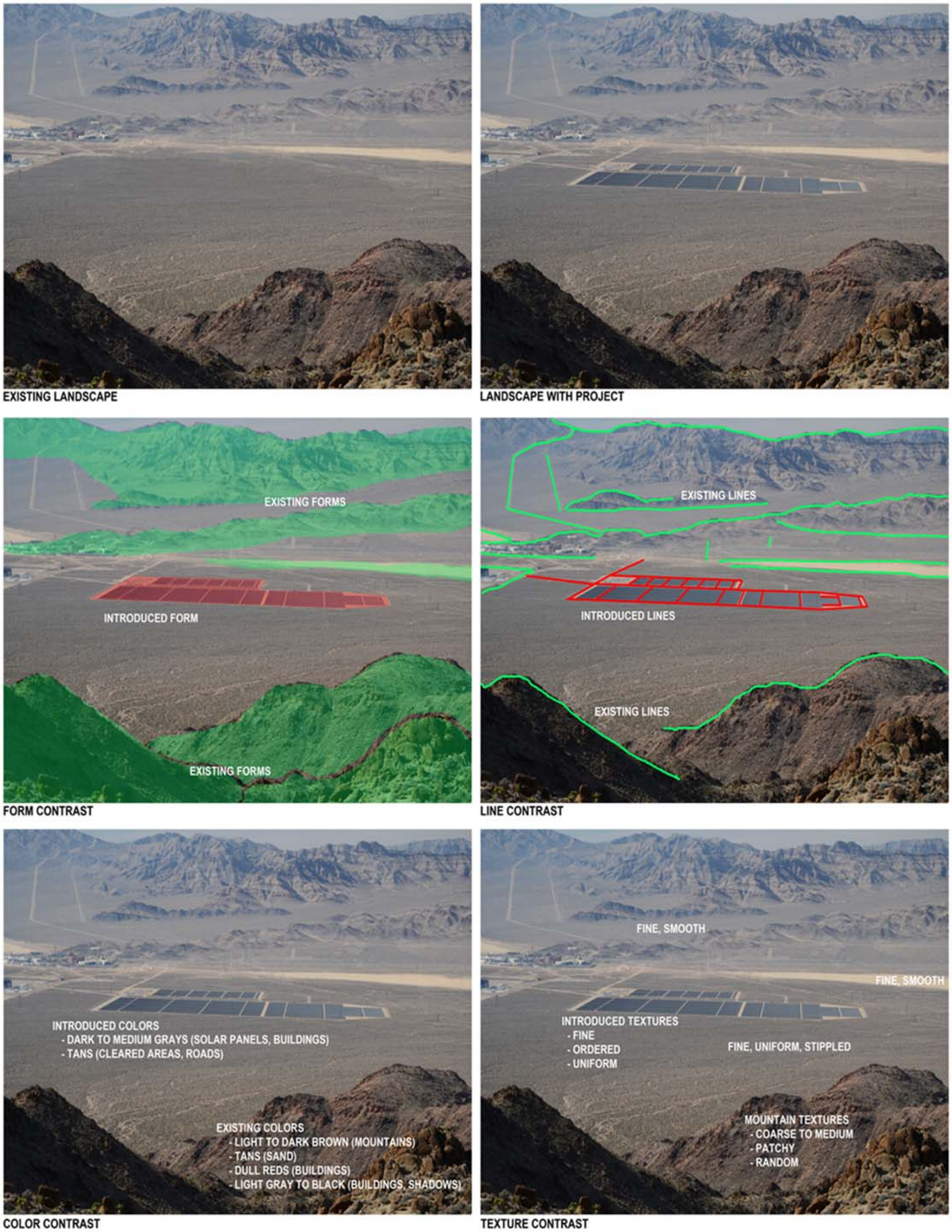


Figure 4.2-1. The Introduction of a Solar Facility to a Desert Landscape Creates Contrasts in Form, Line, Color, and Texture (Credit: Argonne National Laboratory)

The description of visual contrasts should include the expected duration of the visible contrasts and how they would change over the lifetime of the project and afterward. Renewable energy and electric transmission facilities may be in operation for several decades. Specifying the expected duration of visual contrasts is important to gaining an accurate understanding of the potential impacts of the project. For example, contrasts arising from clearing vegetation are frequently strong immediately after construction but typically lessen over time. In some regions of the country, the vegetation contrasts may be reduced substantially in just a few years, and thus would be considered a temporary source of visual impact. However, in desert environments, revegetation may take several decades, and the contrast may remain at strong levels throughout much of the project's lifetime or even beyond, thus essentially constituting a permanent impact for the lifetime of the project.

Similarly, the contrast assessment should address any significant changes in visual contrast that would be expected because of seasonal effects, such as leaf drop and seasonal changes in vegetation color, as well as the presence of snow. Any important changes in appearance of the facility in the course of the day should also be described; these could include the occurrence of glinting and glare from facility components, or silhouetting of components against the rising or setting sun, which may substantially increase visual contrast.

Visual contrasts from facility lighting at night should also be discussed in the VIA. Aviation obstruction lighting on wind turbines and solar power towers and marine hazard navigation lighting on offshore wind turbines can cause significant contrast with dark night skies, as can operations and security lighting at buildings associated with wind and solar facilities, as well as substations. Appendix D discusses studies that have shown that in some landscape settings, aviation obstruction lighting on wind turbines may be visible for more than 35 mi, and aviation obstruction lighting on offshore wind turbines in the United Kingdom has been observed at distance greater than 24 statute miles (Sullivan et al. 2012a; Sullivan et al. 2013a).

The contrast assessment should also describe the expected effects on visual contrast of factors that affect visual perception of objects in the landscape, often referred to as *visibility factors*.

4.2.4 Visibility Factors

A good understanding of the visual contrasts of a proposed facility requires a basic understanding of the visual perception of objects in the landscape. The visibility of an object in a landscape setting and its apparent visual characteristics for any given view are the result of a complex interplay among the observer, the observed object, and various factors that affect visual perception, referred to as *visibility factors*. At a general level, visibility factors can be thought of as factors that determine how easy it is to see an object in a landscape and include such things as the object's distance away from the observer, its size and color, but also the lighting falling on it. Visibility factors are primary determinants of the visual contrasts associated with renewable energy facilities and may have large effects on the distances at which facilities become visible, and the nature and magnitude of the visual contrasts they create. Errors in incorporating visibility factors affect the quality of visual impact simulations. Because many of the factors are highly variable over time, they largely determine the hour-to-hour, day-to-day, and seasonal variation in visual contrasts that are an important part of the visual experience of real landscapes.

Eight major types of visibility factors affect perception of large objects in the landscape:

- Viewshed limiting factors,
- Viewer characteristics,
- Lighting factors,
- Atmospheric conditions,
- Distance,
- Viewing geometry,
- Backdrop, and
- Object visual characteristics.

Viewshed limiting factors include variables associated with accurate viewshed analysis. These are discussed in Appendix A (Viewshed Analysis) and are not addressed further here. The following is a brief summary of the remaining seven visibility factors. A more detailed discussion of each factor can be found in Appendix B (Visibility Factors). All of the visibility factors and their spatial relationships in the landscape are depicted conceptually in Figure 4.2-2.

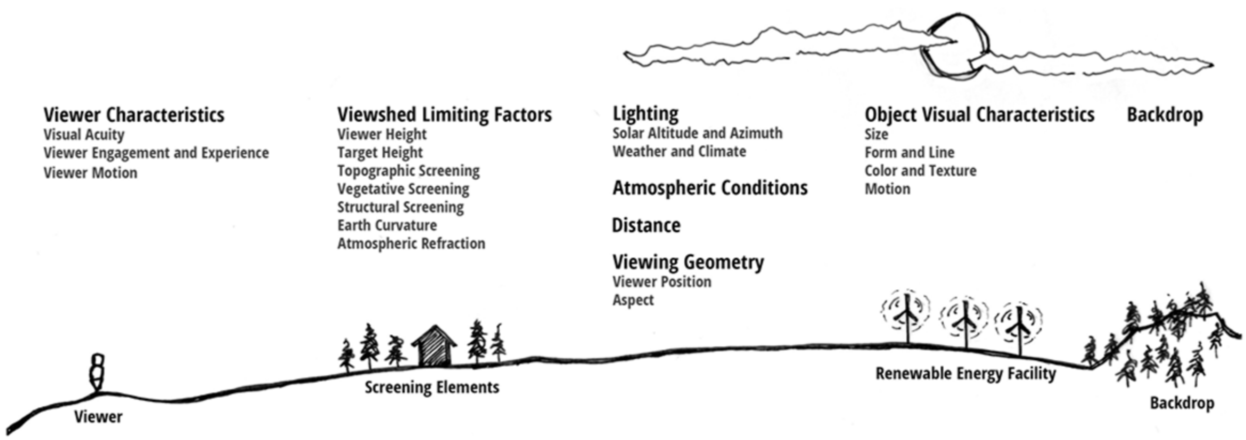


Figure 4.2-2. Schematic Diagram of Visibility Factors (Elements are not shown to scale). (Credit: Argonne National Laboratory)

<u>Viewer Characteristics</u>

Characteristics of the viewer affect the perception of contrast and the ability to discern objects in the landscape.

- *Visual acuity* is the acuteness or clarity of vision. Visual acuity varies from person to person, though major deficiencies are usually corrected by appropriate eyewear. Nonetheless, some viewers are more or less able to distinguish fine details and slight contrasts in the visual field.
- *Visual engagement and experience* refer to how closely the viewer is looking at the landscape, whether he/she is looking for a particular object or type of object, and his/her familiarity with the type of object. Looking more closely at the landscape will reveal details that go unnoticed in a

casual glance, and viewers familiar with particular types of objects (e.g., wind turbines) may spot them more quickly than viewers unfamiliar with them.

- Viewer motion may change the aspect of the viewed facility, and it can also limit the duration of views.

Lighting

The intensity and distribution of lighting has a profound effect on the apparent color of objects and their backgrounds. The angle of sunlight falling on an object may result in shadows that greatly increase its apparent contrast with the background. The sun angle is expressed in two ways:

- Solar altitude (the angle of the sun above the horizon), and
- Solar azimuth (the horizontal angle of the sun, i.e., its compass direction).

Solar altitude and azimuth determine the direction and intensity of lighting on the facilities and the length and direction of shadows cast by facility components, both of which affect facility visibility.

> **TIP**
>
> *Lighting angle and intensity change dramatically in the course of the day, and lighting intensity can change rapidly with the passage of clouds in front of the sun. These changes can have profound effects on the visual contrasts created by facilities, and their appearance can change dramatically as a result. The visual experience of renewable energy facilities (and to a lesser extent transmission facilities) is a dynamic visual experience that differs markedly from the unchanging static view of the facility depicted in visual simulations used in most VIAs.*

Local weather can also greatly affect the visibility and appearance of facilities, primarily by changing the amount and quality of sunlight falling on the facility. A cloud passing in front of the sun changes the light on both the facility and the backdrop and often causes a sudden drop in contrast that may make distant facilities difficult to see. Figure 4.2-3 shows how different wind turbines may appear in different lighting.

Climate will also affect facility visibility and contrast. Regions with sunnier skies and dryer air will, on average, experience higher levels of visual contrast and longer visibility distances for renewable energy facilities than will regions with less sunny skies and higher humidity levels.

Figure 4.2-3. A Passing Cloud Has Shaded the Two Foreground Turbines, Causing a Change in Apparent Color (Credit: Argonne National Laboratory)

<u>Atmospheric Conditions</u>
Water vapor (humidity) and particulate matter (dust, air pollution, and other particles) within the air can affect visibility by scattering and absorbing light coming from an object, which diminishes contrast and subdues colors. Atmospheric conditions may affect the sharpness, brightness, and color of objects and can affect visibility of objects at longer distances, as shown in Figure 4.2-4.

Figure 4.2-4. Atmospheric Haze May Substantially Reduce Visual Contrast of Facilities (Credit: Argonne National Laboratory)

Distance

Distance affects the apparent size and degree of contrast between an object and its surroundings. In general, visual contrasts are greater when objects are seen at close range. If other visibility factors are held constant, the greater the distance, the less detail is observable and the more difficult it will be for an observer to distinguish individual features. Figure 4.2-5 shows the same wind facility at different distances.

In some landscapes, because of their large size and white or highly reflective surfaces, onshore wind and solar facilities may be visible beyond 35 mi in the daytime, and the aviation obstruction lighting on wind turbines and solar power towers may be visible at similar distances at night. Offshore wind facilities may be visible beyond 25 mi. While visibility varies widely by region, VIAs may use areas of analysis that are too small to account for the small but noticeable contrasts visible at longer distances.

Figure 4.2-5. Viewing Distance Affects Visual Contrast (Credit: Argonne National Laboratory)

Viewing Geometry

Viewing geometry refers to the spatial relationship of the viewer to the viewed object (e.g., a renewable energy facility), including the *observer position* and the *bearing* of the view.

- *Observer position* refers to the viewer's elevation with respect to the viewed object: whether the viewer is elevated with respect to the facility and therefore looking downward at it, lower in elevation than the facility and therefore looking upward at it, or level with the facility and looking across the landscape at it.
- *Bearing* refers to the compass direction of the view from the viewer to the object.

Both the observer position and the bearing may have important effects on facility visibility and contrast levels. An elevated view often shows more of the facility and makes it appear larger. The bearing of the view determines which side of the facility is in view and the angle of surfaces with respect to the viewer. Figure 4.2-6 shows how an elevated viewpoint causes a large increase in the visual contrast associated with a low-profile solar facility. Figure 4.2-7 shows how changing the bearing of the view interacts with the lighting on a solar facility to causes dramatic changes in the apparent color of the facility.

TIP

Viewer position greatly affects visibility and can increase or decrease the contrast and visible elements of a project.

Figure 4.2-6. Two Views of the Same Solar Facility from Ground-Level and Elevated Viewpoints Show Increased Visual Contrast for the Elevated View (Credit: Argonne National Laboratory)

The viewer position may have large effects on the visual contrasts created by a facility, especially for solar facilities which have relatively low-height collector arrays and cover large areas. Views from ground level may show the solar collector array as a thin line on the horizon, while views from elevated viewpoints often include the top surfaces of the structures in the facility, causing it to occupy more of the field of view and making the full areal extent and the angular geometry of the facility more apparent. For solar facilities, elevated views also tend to show more of the often highly reflective solar arrays, which can greatly increase visual contrast, especially if glare or glinting occurs.

Figure 4.2-7. Views of the Same Photovoltaic Solar Facility at the Same Time of Day along Different Bearings Show Dramatically Different Apparent Color (Credit: Argonne National Laboratory)

<u>Backdrop</u>

Objects that stand out against the visual backdrop (the background behind the facility) typically command a viewer's attention. As contrast between an object and its background is reduced, the ability to distinguish the object from the background diminishes. When the contrast becomes too small, the object will no longer be visible as separate from its background.

> ***TIP***
>
> *Pay close attention to the visual backdrop of a project because lighting, weather, or seasonal changes dramatically change the visibility of a project.*

The visual backdrop of the facility is a key factor in determining the visual contrasts it creates as seen from a KOP. As shown in Figure 4.2-8, the color and complexity of the background can have a large effect on the visibility of lattice transmission towers. When transmission towers are located on ridges, such that they are silhouetted against a uniform bright sky backdrop (often referred to as skylining), the towers typically are much more visible than they would be against a darker and more varied ground backdrop, and skylined towers are usually visible at longer distances than towers viewed against ground backdrops. On the other hand, sunlit, white wind turbines may be much more visible against dark ground backdrops than they are against bright sky backdrops (see Figure 4.2-9).

When assessing contrasts from proposed projects, and especially when viewing visual impact simulations, it is important for NPS staff to pay close attention to the visual backdrop and lighting of the facility as seen from the KOP. They should understand that the contrasts as portrayed in the simulation may change dramatically as the lighting changes through the course of the day, or as weather or seasonal changes affect the color of the backdrop.

Figure 4.2-8. The Background Can Affect the Visibility of Lattice Transmission Towers (Credit: Argonne National Laboratory)

Figure 4.2-9. White Wind Turbines Visible against a Dark Ground Backdrop (Credit: Argonne National Laboratory)

Object Visual Characteristics

The inherent visual characteristics of the viewed object (e.g., a renewable energy facility) will obviously affect its visibility and the level of visual contrast it creates. The facility and structure size; the scale relative to other objects in view; the form, line, surface colors, and textures of the facility components; and any visible motion of the facility components will all affect the facility's apparent visual contrast.

At certain distances, the movement of wind turbine blades may strongly attract visual attention. Photomontages and other non-animated simulations cannot show blade motion, and thus may under-represent the visual contrasts of the facilities. Although solar collector arrays may change their orientation during the day, the movement is usually very slow and not apparent in short-duration views. Transmission facilities generally do not have moving parts, and, as a result, the viewing experience is less dynamic than wind or solar facilities.

> **TIP**
>
> *Movement can attract visual attention to a project; photomontages may under-represent visibility of a project because they cannot show motion.*

Visual Contrasts of Onshore and Offshore Wind, Solar, and Electrical Transmission Facilities

The observations and recommendations discussed in this section are largely based on various studies sponsored by different federal agencies to identify the visual characteristics of onshore and offshore wind, solar, and electric transmission facilities, and to investigate the effects of distance and other visibility factors on visual contrasts associated with the facilities. These studies are discussed in greater detail in Appendix D. The major sources of visual contrast associated with utility-scale onshore and offshore wind, solar, and electrical transmission facilities are described in the sections below.

4.2.5 Visual Contrasts of Onshore Wind Energy Facilities

This section summarizes the major sources of visual contrast associated with utility-scale onshore wind facilities and discusses their visibility in landscape settings. A detailed discussion of the visual contrasts and impacts of onshore wind energy facilities is available in the Upper Great Plains Wind Energy Programmatic EIS (http://plainswindeis.anl.gov) (Western Area Power Administration and U.S. Fish and Wildlife Service 2013). The VIA in the Plains Wind EIS describes visual contrasts of onshore wind energy facilities and covers all phases of project development, operation, and decommissioning. The discussion below will concentrate on contrasts associated with the operations phase of onshore wind energy facilities. Additional information on visual impacts of specific wind energy facilities in the United States can be accessed in many EISs that are available via the Web.

The primary sources of visual contrast associated with operating onshore wind energy facilities include:

- Vertical line contrasts associated with the wind turbine towers;
- Color contrast from the white tower and blade structures, seen against a sky or ground backdrop (the Federal Aviation Administration [FAA] requires that utility-scale wind turbines be painted white as an aide to aerial navigation safety);

- Form and scale contrast from the height of individual wind turbines and the large expanse of the wind turbine array as a whole;
- Motion of the wind turbine blades;
- Shadow flicker;
- Line, color, and texture contrasts from roads and other cleared areas; and
- Color contrast from aviation obstruction lighting at night.

Other sources of visual contrast include blade glinting (momentary flashes of reflected light from turning turbine blades); and form, line, color, and texture contrasts from substations, meteorological towers, and from ancillary structures, such as administration or maintenance buildings. Various sources of visual contrasts associated with wind facilities are shown in Figures 4.2-10 through 4.2-12.

Figure 4.2-10. Wind Turbines on a Mountain Ridge in Maine (Credit: James F. Palmer, Burlington, Vermont)

BLM-sponsored research has investigated the visual characteristics and visibility of utility-scale wind facilities in western landscapes and the key factors affecting project visibility (Sullivan et al. 2012a). The study results, based on turbines of moderate height by current standards (383–404 ft at blade tip height), suggest that in western landscapes an appropriate area of impact analysis for a utility-scale wind energy facility would be 30 mi, as an approximate limit of non-negligible contrasts, though it should be noted that the wind turbines might be visible beyond this distance in some cases, both during the day and at night. Wind facilities have been documented to be visible at distances of nearly 49 mi (Cownover 2013), though this is exceptional.

There is little documentation of wind turbine visibility in Midwestern or eastern U.S. landscapes. These regions generally have poorer visibility than the western United States because of increased humidity and air pollution, with visibility further diminished due to flat to rolling terrain, land use, and landcover characteristics. It is unlikely that wind facilities would be visible at the longer distances they are in many western landscapes. Areas of impact analysis may sometimes be set as low as 8 mi from the project, presumably based on professional judgments about the likely radius of substantial contrasts. With turbine size constantly increasing, in some situations an area of analysis of 8 mi may be too small.

The short, dark vertical lines of wind turbines silhouetted against the sky can be visible for long distances, and, similarly, sunlit turbines may be conspicuous against darker vegetation, rock, or dark cloud backgrounds. Although the individual turbines may appear to be very small, because wind facilities typically have many turbines spread out over a wide area (the largest wind facilities may cover several hundred thousand acres), even a distant facility may occupy a significant portion of the *horizontal field of view* (the horizontal extent of the human view) and be easily noticeable, though not causing strong visual contrast. On flat ground such as plains or mesas, the mass of wind turbines may appear as a banded but not solid form at long distances.

At shorter distances, the blade motion becomes visible, which may add substantially to visual contrasts. At even shorter distances, although the individual wind turbines may still not appear particularly large, large wind facilities may stretch across much of the visible horizon and the sweeping blades may strongly attract and hold attention.

Although utility-scale wind turbines are very tall (currently they may be the size of 35- to 60-story buildings; e.g., 350–600 ft), they are very narrow and lack "visual mass." Their visibility depends greatly on whether they are sunlit or shaded and the interaction of turbine lighting with the lightness, color, and complexity of the background, as shown in Figure 4.2-13.

Figure 4.2-11. Ancillary Structures at a Wind Energy Facility (Credit: Argonne National Laboratory)

Figure 4.2-12. A Wind Facility Substation (Credit: Argonne National Laboratory)

When evaluating wind turbine contrasts, it is important to consider the spatial relationship of the KOP, the wind facility, and the apparent path of the sun across the sky in the course of the day. For example, wind facilities to the east of the KOP with a sky backdrop will be silhouetted by the rising sun in the morning, but if viewed against a ground backdrop they may be difficult to see. In the afternoon, the turbines will be lit by the setting sun, and the white towers may be very conspicuous against a darker vegetation or rock backdrop. Facilities west of the KOP will be sunlit in the morning and shaded in the afternoon. Because the sun is in the southern sky most of the year, wind turbines south of a KOP will seldom be sunlit but will often be silhouetted by the sun behind them. Facilities north of a KOP will almost always have at least some sun on them, and this may greatly affect their overall visibility.

Figure 4.2-13. Three Views of the Same Wind Farm in Wyoming at Distances between 6 and 10 mi Illustrate How the Complex Interaction of Viewing Geometry, Lighting, and Visual Backdrop Affect Visibility (Credit: Argonne National Laboratory)

To avoid collisions with aircraft, the turbines in utility-scale wind energy facilities must be lighted at night. Night-sky contrasts of utility-scale wind facilities can be substantial, particularly in rural or undeveloped areas, where there are few other light sources and there is a uniform and generally featureless dark background (see Figure 4.2-14). In recently built facilities, not every turbine has an aviation obstruction light; however, in a large facility, dozens or even hundreds of turbines may have the red flashing lights and the flashing is synchronized, so that all of the lights flash on and off at the same time. For viewers near to the wind facility, the flashing effect can be very conspicuous and is a unique visual experience. As Sullivan et al.'s (2012a) study demonstrated, the lights can be visible for very long distances. While they may not be as bright as other visible lights at long distances, the synchronized flashing makes them more conspicuous and instantly recognizable as wind facilities.

Figure 4.2-14. Hazard Navigation Lighting atop Wind Turbines (Credit: Terrence J. DeWan & Associates)

A recently developed technology, the Audio Visual Warning System (AVWS), is a radar-based obstacle avoidance system that activates obstruction lighting and audio signals only when an aircraft is in close proximity to an obstruction on which an AVWS unit is mounted, such as a wind turbine. The obstruction lights and audio warnings are inactive when aircraft are not in proximity to the wind turbine. Currently, the FAA has not approved the general use of AVWS for wind facilities. The FAA may approve use of AVWS on a case-by-case basis. If approved by the FAA for general use, AVWS technology would greatly reduce the night-sky impacts of lighting from wind facilities.

As the number of wind facilities in the United States rapidly increases, the likelihood of cumulative visual impacts will be increasingly common. NPS staff reviewing VIAs should consider issues of wind facility intervisibility (seeing multiple wind facilities from one KOP) and sequential viewing (seeing facilities in succession while moving through the landscape).

4.2.6 Visual Contrasts of Offshore Wind Energy Facilities

This section summarizes the major sources of visual contrast associated with utility-scale offshore wind facilities and discusses their visibility in seascape settings. A more complete discussion of the visual contrasts and impacts of offshore wind energy facilities is available in the Outer Continental

Shelf Alternative Energy Final Programmatic EIS (OCS Programmatic EIS), available at: http://www.boem.gov/Renewable-Energy-Program/Regulatory-Information/Guide-To-EIS.aspx (MMS 2007). The VIA in the OCS Programmatic EIS describes visual contrasts of offshore renewable energy facilities, including offshore wind, and covers all phases of project development, operation, and decommissioning. The discussion below concentrates on contrasts associated with the operation of offshore wind energy facilities. Additional information on the visual impacts of specific offshore wind energy facilities in Europe and the Cape Wind Project (MMS 2009), the first permitted offshore wind project in the United States, can be accessed via the Web.

As of the time of this publication, there are no utility-scale offshore wind facilities in operation or under construction on the Atlantic, Pacific, or Gulf coasts of the United States, or in the Great Lakes; however, the Cape Wind Project has been permitted, and other offshore lease tracts are currently being designated and offered by BOEM. Various projects are in the planning stages, and there is little doubt that utility-scale offshore wind facilities will be built off the U.S. ocean coasts and perhaps the Great Lakes coasts within the next 5 years. Currently, there are numerous facilities off the coasts of various western European countries, and some limited research has been conducted to assess their visibility and the visual contrast they create.

The primary sources of visual contrast associated with operating offshore wind energy facilities include:

- Vertical line contrasts associated with the wind turbine towers;
- Color contrast from the white or light gray tower and blade structures, generally seen against a sky backdrop when viewed from shore but occasionally viewed against a water backdrop from elevated onshore locations;
- Form contrast from the array as a whole;
- Motion of the wind turbine blades;
- Color contrast from aviation obstruction lighting at night; and
- Color contrast from marine navigation lighting at night.

Other sources of visual contrast include blade glinting (momentary flashes of reflected light from turning turbine blades); color contrasts from marine paint (yellow) at the base of the towers for marine hazard navigation; and form, line, and color contrasts from electrical service platforms, which are essentially offshore substations. Figure 4.2-15 shows a small offshore wind facility in the United Kingdom.

BOEM-sponsored research has investigated the visual characteristics and visibility of utility-scale offshore wind facilities in the United Kingdom and the key factors affecting project visibility (Sullivan et al. 2013a). The study results suggest that an appropriate area of impact analysis for an offshore utility-scale wind energy facility would be 25 mi, as an approximate limit of non-negligible contrasts, though it should be noted that the wind turbines might be visible beyond this distance in some cases. It is important to note that the study results are based on turbine heights up to 500 ft. Taller turbines might be visible for longer distances and could require a larger area of analysis.

Figure 4.2-15. Burbo Bank Offshore Wind Facility in the United Kingdom (Credit: Argonne National Laboratory)

In the absence of islands or other land backdrops, most sea views are visually very simple, and views are dominated by the sea/sky horizon line. The often stark white, light gray, or very dark (when silhouetted or shaded) vertical lines of offshore wind turbines are thus particularly noticeable as the eye scans along the horizon line, even though the turbines may not appear to be particularly large.

The visually simple seascape also makes blade movement more noticeable than it likely would be in a more complex and varied land or vegetation backdrop. From certain onshore locations, where offshore wind facilities are laid out in regularly spaced grids, viewers at certain onshore locations may be looking down parallel rows of turbines that form a striking symmetrical arrangement that tends to command and hold visual attention (see Figure 4.2-16).

Figure 4.2-16. Parallel Rows of Turbines in an Offshore Wind Facility (Credit: Argonne National Laboratory)

Where one offshore wind facility is located relatively far from shore, it may be visible beyond and through a closer offshore facility, so that from an onshore viewing location, the two sets of turbines appear to be "mixed," a type of cumulative visual impact. The mixing of two different tower designs, spacings, and heights often creates a cluttered and disordered look that may attract and hold visual attention. In some cases, having multiple non-overlapping wind facilities in view may make it difficult to view the seascape without having to look at wind turbines, another type of cumulative visual impact. While it may be a number of years before multiple wind farms are built in close proximity to one another in U.S. waters, it is likely that these types of cumulative impacts will become increasingly common with time.

It is important to note that for technical reasons, offshore wind turbines may be larger than onshore wind turbines. There are currently 6-MW wind turbines in production that are almost 650 ft tall from the water surface to blade tip. Larger turbines are likely to cause greater visual contrasts at a given distance and to be visible at longer distances. The trend is toward developing ever larger turbines, and a 10-MW turbine is currently under development, with a blade tip height exceeding 720 ft. It is very important that NPS staff consider turbine size, as well as number, when evaluating contrast assessments and also when evaluating the areas of impact analysis used in EISs, because the areas may not be adjusted by the impact analyst to account for larger turbines.

> **TIP**
>
> *Analysts may not adjust the area of impact to reflect the turbine size. Average wind turbine height has steadily increased over the last several decades and is expected to continue to do so.*

The U.K. offshore wind turbine visibility study (Sullivan et al. 2013a) also showed that aviation obstruction lighting on offshore wind turbines was sometimes visible beyond 24 statute miles from onshore locations. Figure 4.2-17 shows a moderately sized offshore wind facility in the United Kingdom at night. As part of a BOEM-funded study of impacts (primarily ecological) associated with offshore wind lighting, Orr et al. (2013) present detailed information on lighting configurations used in more than 30 offshore wind facilities throughout the world.

Figure 4.2-17. Thanet Offshore Wind Facility at Night (Bright light at center is an electrical service platform.) (Credit: Argonne National Laboratory)

4.2.7 Visual Contrasts of Solar Energy Facilities

This section summarizes the major sources of visual contrast associated with utility-scale solar energy facilities and discusses their visibility in landscape settings. A detailed discussion of the visual contrasts and impacts of solar energy facilities is available in the Solar Energy Development Programmatic EIS (BLM and DOE 2012), available online at: http://solareis.anl.gov. The VIA in the

Solar EIS describes visual contrasts of several types of solar energy facilities and covers all phases of project development, operation, and decommissioning. The discussion below will concentrate on contrasts associated with the operations phase of solar energy facilities. Additional information on visual impacts of specific solar energy facilities in the United States can be accessed in many EISs that are available via the Web.

Three main classes of utility-scale solar energy facilities are in use in the United States. Within each group, there are variants that employ slightly different components that give rise to differing visual contrasts; but within each main type, the contrasts are generally similar.

Solar Power Tower Facilities—Power towers typically use tens of thousands of large flat mirrors (heliostats) to reflect sunlight onto the top of a very tall tower (typically 400 to 800 ft tall) (see Figures 4.2-18 and 4.2-19). The heliostats track the sun during the course of the day to maximize the amount of sunlight concentrated onto the tower. The top portion of the tower is made of a special material that absorbs the sunlight and uses the heat from the sunlight to heat a fluid inside the tower to extremely high temperatures. The fluid is circulated through the tower to a steam turbine generator (STG), where the heat from the fluid is used to create steam that drives a conventional steam turbine to generate the electricity, which is fed to an electrical substation that connects to the electrical grid.

Figure 4.2-18. Receiver Tower and Heliostat Array of the Ivanpah Solar Energy Generation Facility, Less Than a Mile from Mojave National Preserve. The view from the Park is elevated. (The receiver is not illuminated in this photograph). The heliostat array is approximately 1.3 mi in diameter; there are three towers in the facility. (Credit: Argonne National Laboratory)

Solar Parabolic Trough—Parabolic trough facilities also use mirrors to reflect sunlight, but the mirrors are curved and are arranged in long parallel rows (troughs) generally about 20 to 30 ft above

the ground (See Figures 4.2-20 and 4.2-21). The curved mirrors focus the reflected sunlight onto tubes that run parallel to the mirrors and are located just above the mirrors. The reflected sunlight heats a fluid in the tubes to very high temperatures, and, similarly to the power towers, the heat from the fluid is pumped to an STG to drive a steam turbine to generate electricity, which is fed to a substation connected to the electrical grid. The mirrors track the sun from east to west over the course of the day to maximize the amount of sunlight falling on the tubes.

Figure 4.2-19. Illuminated Receiver Tower of a 20-MW Power Tower Facility in Spain (Credit: Argonne National Laboratory)

Figure 4.2-20. Mirrors of a Parabolic Trough Facility (Credit: Argonne National Laboratory)

Figure 4.2-21. A Parabolic Trough Facility as Seen from an Elevated Viewpoint 4 mi Away (Credit: Argonne National Laboratory)

Photovoltaic (PV) Facilities—Conventional PV facilities are fundamentally different from power tower and parabolic trough facilities in that they do not involve the generation of heat to drive a steam turbine to generate electricity. Instead, thousands of sunlight-absorbing solar panels convert the sunlight that falls on them directly into electricity (see Figures 4.2-22 and 4.2-23). The electricity generated by the panels is fed into power conversion units which are housed in small structures scattered throughout the collector array. Underground cables feed the electricity into a substation for connection to the electrical grid. Conventional PV facilities do not use mirrors to reflect or concentrate sunlight, although there is a small subset of PV facilities called **concentrating PV facilities** that do use mirrors or lenses to concentrate the sunlight onto the solar panels. There are several types of PV technologies, and, depending on the facility, the panels may or may not track the sun during the course of the day, and this affects the appearance of the facility and how its components reflect light.

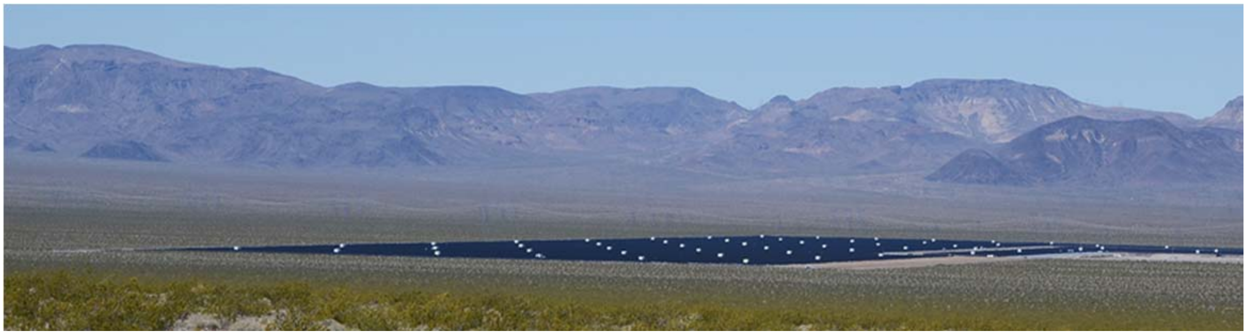


Figure 4.2-22. A Thin-Film PV Facility Seen from a Slightly Elevated Viewpoint about 2 mi Away (Credit: Argonne National Laboratory)

For economic reasons, utility-scale solar facilities are concentrated in the southwestern United States. In fact, power tower and parabolic trough facilities are effectively limited to the southwestern states because they require very strong direct sunlight to reach acceptable levels of generation efficiency. PV systems do not have the same limits on direct solar radiation, and thus utility-scale PV facilities are found in some states outside the southwestern United States. However, there are far fewer facilities outside the southwestern states and they tend to be much smaller.

Figure 4.2-23. PV Solar Panels Convert Sunlight Directly into Electricity (Credit: Argonne National Laboratory)

The following list presents the primary sources of visual contrast associated with operating solar energy facilities. Because there are several types of solar technologies, the types of visual contrasts associated with the facilities vary, and not all of the contrasts listed below would be associated with every type of facility. The primary sources of visual contrast associated with operating solar energy facilities include:

- Form and line contrasts from changes to landform (not all facilities require landform changes such as site grading);
- Color and texture contrasts from vegetation clearing or management;
- Form, line, color, and texture contrasts from the solar collector/reflector array (see Figures 4.2-24, Figure 4.2-25, 4.2-6, and 4.2-7);
- Form, line, color, and texture contrasts from STGs (power towers and parabolic trough facilities only), and cooling towers (power towers and parabolic trough facilities using wet or hybrid cooling only) (see Figure 4.2-24);
- Scale contrasts because of the large extent of the collector/reflector arrays for all types of solar facilities and the height of receiver towers (power towers only) (see Figure 4.2-18);
- Line, color, and texture contrasts from roads;

Figure 4.2-24. Several Views of the Same Parabolic Trough Facility from Different Angles and under Different Lighting Conditions Show a Wide Range of Color Contrasts, Including Glare (Second Image from top) (Credit: Argonne National Laboratory)

- Movement and color contrast from water vapor plumes (for some power towers and parabolic trough facilities only);
- Glare and glinting from solar collectors/reflectors (see Figures 4.2-26, 4.2-27, and 4.2-19);
- Other light reflections from solar collectors/reflectors and ancillary components such as wind fences and site boundary fences; and
- Color contrast from facility lighting at night (see Figure 4.2-29).

Figure 4.2-25. Small (<550 acres) PV Arrays (black) and a Parabolic Trough Facility (white) Viewed from a Mountaintop 10 mi Away (Credit: Argonne National Laboratory)

Other sources of visual contrast include color contrast from aviation obstruction lighting (for power towers only) both during the day (typically white strobe lights) and at night (typically slowly flashing red lights); and form, line, color, and texture contrasts from transmission lines and substations, and from ancillary structures, such as administration or maintenance buildings.

Figure 4.2-26. Glare Spot on a Parabolic Trough Facility (Credit: Argonne National Laboratory)

Currently, operating and planned utility-scale solar facilities occupy several hundred to several thousand acres, most of which are devoted to the solar collector/reflector array. Typically, the arrays are arranged in rectangles, circles, or other straight-sided polygons, which are densely packed with rows of collectors. The collector arrays are generally low in height, and thus may be screened from view by tall vegetation, structures, or terrain. However, power towers and parabolic trough facilities have other infrastructure elements, such as the building that houses the STG and steam cooling structures, which are much taller than the reflector arrays and are much harder to screen.

The most conspicuous element of power tower facilities is the power tower itself, often referred to as the central receiving tower. Receiver tower height and design vary, but they typically are poured concrete or steel structures ranging in height from about 400 to 800 ft, and so they are usually much taller than any nearby structures in the desert areas where they are typically found (see Figures 4.2-18 and 4.2-19). When the facility is in operation and the sun is shining, the top portion of the tower structure is very brightly illuminated by the reflected light from the tens of thousands of heliostats in the reflector array, to the extent that the top of the tower appears to glow a brilliant white (see Figure 4.2-27). If there is sufficient particulate matter in the surrounding air, faint streamers of reflected sunlight may radiate both diagonally upwards and downwards from the receiver, as shown in Figure 4.2-19. The overall visual effect of the streamers is unique and dramatic and visible for at least several miles. BLM-, NPS-, and U.S. Department of Energy (DOE)-sponsored research on the visual characteristics of solar energy facilities has shown that the receiver tower structures may be visible for very long distances, even when the towers are not illuminated by the heliostats (Sullivan et al. 2013b).

Figure 4.2-27. Glare from a 20-MW Power Tower (Credit: Argonne National Laboratory)

The research cited above has also shown that both power towers and parabolic trough facilities are capable of creating strong glare; that is, reflected light bright enough to cause annoyance, and, in some cases, for distances of at least 10 mi (see Figures 4.2-26, 4.2-27, and 4.2-19). Depending on the facility, glare may be observed at various times throughout the day at different times of the year and appears to be a daily occurrence. It may be painfully bright in some circumstances.

PV facilities do not have STGs and the associated infrastructure, such as cooling towers, cooling ponds, water vapor plumes, and piping that both power towers and parabolic trough facilities have. PV facilities use lower profile structures (typically 6–20 ft), and they also utilize black panels rather than the silvered mirrors that power towers and parabolic troughs use. Thus they are less subject to glinting and glare than power towers and parabolic trough facilities, although PV facilities can and do cause glare from sunlight reflected off the surface of the panels. PV facilities need very few employees to run the facilities, so there are fewer vehicles and less worker activity than at trough and power tower facilities. Fewer workers and structures at PV facilities mean less lighting is required at night than at power tower and parabolic trough facilities. They do not need the site grading that parabolic trough facilities require to ensure efficient transport of the heat transfer fluid (although the sites are sometimes graded nonetheless). For these reasons, in general, PV facilities have substantially lower visual contrasts than either parabolic trough or power tower facilities. However, some PV facilities may be subject to dramatic changes in color because of reflected sunlight/sky off the reflective glassy surfaces of the panels, despite the black color of the underlying PV material, as shown in Figure 4.2-7.

TIP

For a variety of reasons, vegetation clearing and site leveling are sometimes implemented for PV facilities, but depending on the project and site characteristics, may not be necessary. NPS staff should consider pressing for avoidance of these practices unless absolutely necessary, and where these practices are necessary, that they be minimized.

Concentrating PV designs vary but sometimes involve the placement of a sheet of Fresnel lenses in front of the PV panels, which are mounted on pedestals much taller than normal PV panels; the assemblies may be as high as 40 ft and resemble very large tilted tables on pylons (Figure 4.2-28). They generally track the sun precisely to maximize the sunlight concentrated on the panels. In some instances, they may cause bright light reflections visible for very long distances (25 mi or more).

Figure 4.2-28. Concentrating PV Facility (Credit: Argonne National Laboratory)

In the course of the research cited above (Sullivan et al. 2013b), it was noted that the occurrence of glare at parabolic trough facilities is highly dependent on viewing geometry, that is, the relative positions of the observer, the glare-causing elements of the facility, and the direction of the sunlight. The glare may increase or decrease dramatically in just a few seconds or minutes, whether in response to slight changes in the observer's position, or because of changes in mirror orientation as they track the sun.

Limited observations of solar facilities at night suggest that ground-based lighting at the facilities may be visible for long distances (13 mi and likely more). Power tower central receiving towers are tall enough that they would require aviation obstruction lighting. Multiple flashing white strobe lights on a facility under construction in the United States were visible beyond 20 mi from the facility during the day. Figure 4.2-29 shows lighting at a parabolic trough facility.

Figure 4.2-29. Lighting at a Parabolic Trough Facility (Credit: Argonne National Laboratory)

Because of the variety of solar technology types, the relatively small number of facilities in operation (especially large facilities), and less extensive research on the visibility of solar projects, suggesting an appropriate area of impact analysis is difficult. The BLM-, NPS-, and DOE-sponsored research to date suggests that for most non-concentrating PV facilities, an area of analysis of 25 mi would likely be sufficient, though some PV facilities might not be visible at all at those distances, depending on the topography and viewpoint elevation and orientation. A larger area of analysis is clearly appropriate for power towers, as the unlit towers at large facilities have been shown to be visible from beyond 30 mi. It is likely that if there are long enough sight lines, the light from operating power towers will be clearly visible beyond 40 or even 50 mi, and distances beyond that are certainly possible.

4.2.8 Visual Contrasts of Electric Transmission Facilities

This section summarizes the major sources of visual contrast associated with high-voltage electric transmission facilities and discusses their visibility in landscape settings. A detailed discussion of the visual contrasts and impacts of transmission facilities is available in the West-Wide Energy Corridor Programmatic EIS (DOE and DOI 2008), available online at: http://corridoreis.anl.gov. The VIA in the EIS describes visual contrasts of transmission facilities and covers all phases of project development, operation, and decommissioning. The discussion below will concentrate on contrasts associated with the operations phase of transmission facilities. Additional information on visual impacts of specific transmission projects in the United States can be accessed in many EISs that are available via the Web.

Although there are many transmission tower types that vary widely in design, size, and materials, three major types are lattice towers, monopoles, and H-frames (see Figure 4.2-30). While there is overlap in the size range by voltage, in general, the majority of operating higher voltage towers in the United States (500 kV and above) are lattice towers, and the majority of lower voltage towers are H-frames or monopoles, although H-frames and monopoles are sometimes employed for higher voltage lines.

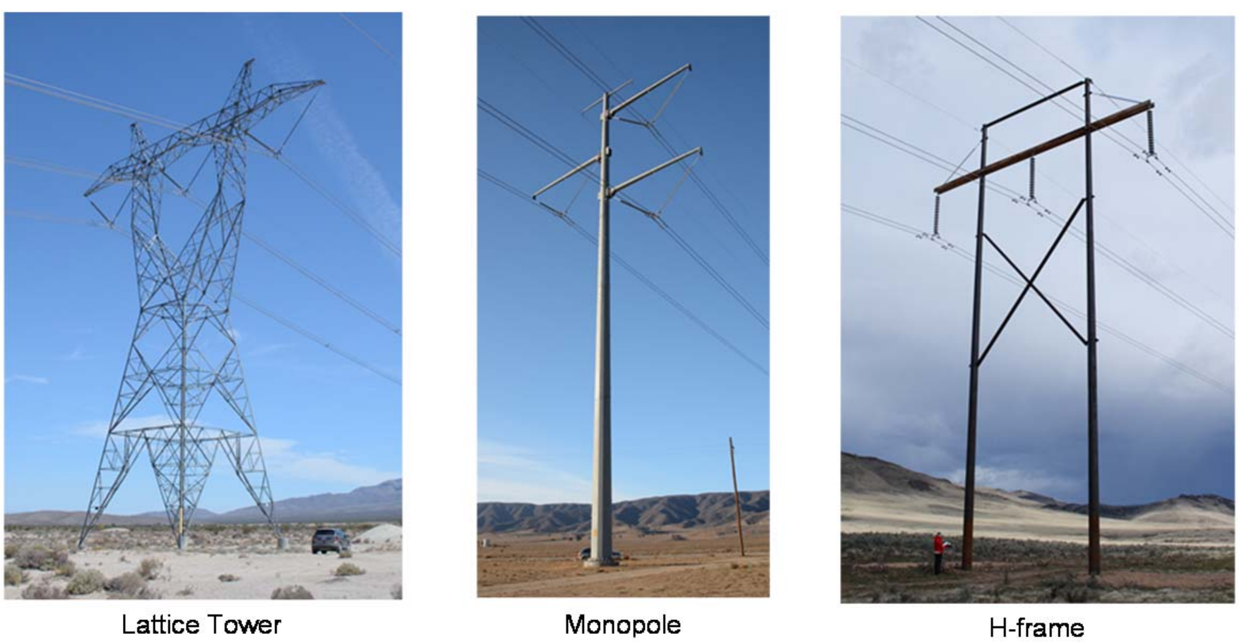


Figure 4.2-30. Primary Transmission Tower Types (Credit: Argonne National Laboratory)

Most transmission towers are made of steel, but some smaller towers (generally H-frames) are constructed of wood. Surface treatments include unpainted galvanized steel; the rusted brown surface of Corten steel; paint (often white); or the dark brown of wooden poles. Heights vary widely but rarely exceed 200 ft, the height at which FAA obstruction lighting would be required. Consequently, transmission lines generally do not have lighting; however, important exceptions include towers near airports, towers used to cross rivers, and other areas where they might pose a special hazard to air navigation.

The primary sources of visual contrast associated with operating transmission facilities include:

- Form, line, and color contrast from transmission tower structures;
- Color and texture contrasts from vegetation clearing or management on the ROW where clearing and vegetation management are required;
- Line, color, and texture contrasts from roads;
- Line contrast and sometimes reflections from the conductors (the transmission cables);
- Refracted light from glass insulators where they are used; and
- Form, line, and color contrast associated with substations and associated roadways, fencing, and landform alterations.

Other sources of visual contrast include bird deflectors and aerial marker balls that are attached to the conductors; guy wires used to support certain types of lattice towers; and aviation obstruction lighting on towers in certain situations, as noted above.

The limited research available on high-voltage transmission facility visibility suggests that transmission tower visibility is highly dependent on the color and visual complexity of the background. A dark and more visually complex background, such as rough textured shrubs, is better able to “mask” the towers than more uniform, finely grained, and lighter backgrounds such as dried grasses, sand, or the sky. A recent study found that lattice towers viewed against sky backdrops are visible at longer distances and are generally more visible at a given distance than towers viewed against ground backdrops (Sullivan et al. 2014). Figure 4.2-31 shows skylined transmission towers. The same study found that 500-kV lattice transmission towers in western landscapes are sometimes plainly visible at distances of up to 10 mi, although the individual towers appear very small at that distance. In addition, the study found that the 500-kV lattice towers became a major focus of visual attention at distances of up to 3 mi; smaller H-frame towers are substantially less visible than larger lattice or monopole towers. The study did not find large differences in visibility between lattice and monopole towers overall.

Visible access roads and cleared ROWs in forested landscapes can greatly increase visibility of transmission facilities; at long distances, the cleared ROW may be visible even though the towers are not. Figure 4.2-32 shows a cleared transmission ROW. Cleared ROWs have been observed at 40 mi, and individual towers at distances of 23 mi, but in these observations, the objects were at the limit of visibility; that is, barely discernible (Jones and Jones 1976). One study conducted in the Pacific Northwest recommended much smaller practical areas of impact analysis, ranging from 1.4 to 8.2 mi depending on the tower size and landscape setting for transmission facilities not requiring cleared ROWs (Jones and Jones 1976). The study recommended far larger areas of analysis for transmission facilities with cleared ROWs, ranging from 1.5 mi for an 80-ft ROW to 24.3 mi for a 640-ft ROW.

Figure 4.2-31. Skylining Makes These 500-kV Lattice Towers Visible at 8 mi (Credit: Argonne National Laboratory)

Figure 4.2-32. Cleared ROWs in Forested Areas Can Be Visible for Very Long Distances (Credit: BLM)

It is important to consider the angle of view from the KOP to the transmission facility when assessing contrast. Transmission lines are long linear features, and when they are perpendicular to the line of sight, they may stretch across the entire horizon, which may greatly increase their visibility, even though at distances beyond a few miles, the individual towers appear to be very small. Viewed at oblique angles, they may occupy only a small part of the field of view, but the view “down the line” results in a cluster of towers being visible in a small area, apparently “stacked” on top of each other, in a dense and visually cluttered way that may also make them more visible.

It is very common for multiple transmission facilities to be located in the same ROW. Multiple-line ROWs are usually wider than single-line ROWs, and where vegetation clearing is required, the wider ROWs may be more visible. Typically, the individual transmission facilities within the ROW differ in size, design, and materials, which creates additional visible contrasts and often causes “visual clutter.”

Most transmission towers have unpainted galvanized surfaces that can make them highly reflective, even capable of causing glare in some situations. Weathering will eventually dull the finish to reduce the reflectivity substantially, but this process can take years, and it is highly desirable to dull the surface as part of the manufacturing process through treatment with non-glare coatings.

> **TIP**
>
> *The best possible way to gain an accurate understanding of the visual contrasts of renewable energy and transmission facilities is through direct observation of similar facilities in real landscapes. NPS staff are strongly encouraged to visit nearby facilities for first-hand observation, preferably repeated observations in a variety of weather and lighting conditions. GPS or other tools should be used to determine the viewing distance.*

The conductors may be visible at short distances, especially against a sky backdrop, and occasionally at much longer distances. The use of "non-specular" conductors (i.e., conductors treated to reduce their reflectance) can greatly reduce their visibility; otherwise, they will eventually weather to a more dull finish.

Substations are an important component of the visual contrasts from transmission facilities. Substations vary in size and configuration but may cover several acres; they are cleared of vegetation and typically surfaced with gravel. They are fenced and graded and are reached by an associated access road. In general, substations include a variety of structures, conductors, fencing, lighting, and other features that result in a visually complex and "industrial" appearance.

4.2.9 Description of Direct Impacts

The VIA should include discussion of the anticipated direct visual impacts of the proposed project and any alternatives under consideration. Direct visual impacts are caused by the project itself and normally constitute the bulk of visual impacts from the project. Visual impacts from all visible components of the project (including ancillary facilities such as roads, substations, and the transmission line connecting the facility to the electrical grid) and all visible activities connected to the project and occurring at the project location throughout all phases of the project (site assessment, construction, operation, and decommissioning) are considered to be direct impacts. Indirect impacts (discussed below) occur away from the project location, in a spatial and/or temporal sense.

As noted in Section 3.1, visual impact is both the change to the visual qualities of the landscape resulting from the introduction of visual contrasts from the project and the human response to that change. Thus, the description of direct impacts in typical VIAs has two parts, though they may be presented together: a discussion of the impacts of the project on the scenic qualities and landscape character of the surrounding landscape setting, and a discussion of the impacts on persons who might view the project area from KOPs and other locations within the project viewshed.

The description of impacts should be specific about the scenic qualities that would be affected by the project, including changes to the physical setting, but also changes to landscape character, defined by the USFS as "an overall visual and cultural impression of landscape attributes; the physical appearance and cultural context of a landscape that gives it an identity and 'sense of place'" (USFS 1996). For example, the introduction of a large wind facility to an existing rangeland landscape might change the landscape character in the project vicinity from "pastoral" to "industrial." Similarly, the introduction of a transmission line to a historical landscape could potentially affect the historic qualities of the landscape setting.

For projects on lands administered by agencies that have established visual resource management systems, there may be prescribed methods for describing impacts. For projects on BLM-administered lands, potential impacts on scenic quality, as expressed by BLM VRI values, should be discussed, along with discussion of conformance of the proposed project with the applicable VRM class for the project area. VIAs for projects on USFS lands would compare predictions of future visual conditions with the Desired Condition and Scenic Integrity Objectives described in the applicable USFS Forest Plan, consistent with the USFS SMS. The VIAs also need to discuss any visual impacts on units of the National Park System and other special status areas that could be affected by the project.

> **TIP**
>
> *Evaluators should look at the visual contrast description closely. Look carefully at the simulations and consider impacts on other areas not shown in the simulations, as well as the dynamic visual effects (e.g., blade motion, water vapor plumes, and glare) that may not be shown in the simulations. If possible, bring the simulation out into the field at the KOPs to compare the simulation with the view of the real landscape/seascape. Examine the viewer information for accuracy and completeness. Then, examine the impact assessment closely to determine whether the assigned impact levels are reasonable, and raise questions when necessary.*

Impacts on viewers are usually described qualitatively; for example, a wind VIA might state that the view of a wind farm from a wilderness area might interfere with a wilderness user’s perception of the naturalness of the visual environment.

Criteria for assigning visual impact levels (the magnitude of the impacts) vary widely. Some states and other jurisdictions have more or less well-defined criteria for assessing the degree of visual impact from a project (e.g., Maine Wind Energy Act of 2003). In many cases, however, there are no criteria defined, or the criteria are not specific, and there is a greater or lesser degree of professional judgment on the part of the analyst involved. In high-quality VIAs, the analysis will include all applicable laws and regulations that apply to visual resource protection and include specific reference to meeting existing visual management objectives. It will also include applicable rationale or criteria for assigning impact levels.

The determination of impact magnitude should be based in part on viewer information; that is, the number of viewers, the typical duration of views, and the sensitivity of the viewers to changes in the visual setting, which is a function of viewers’ attitudes, individual preferences, the activity in which they are engaged while viewing the project, and their expectations for scenic quality. This information should be determined for each KOP, and the information should be factored into the impact determination for each KOP.

> **TIP**
>
> *NPS staff should determine whether the impact assessment incorporates the effects of mitigation measures into the determination of impact magnitude, and if it does, should ensure that the mitigation is, in fact, required as identified in the NEPA documents for the project.*

Typically, analysts rely heavily on the visual simulations prepared for the VIA as the basis for impact determination, in part because the simulations are the most realistic representation of what the project will actually look like when it is built. However, while simulations are a very useful tool for VIA, they have important limitations (see Section 5.5) and are subject to various errors (see Section 5.6) both in production and in presentation. They do not always portray contrasts accurately, and, in some situations, they may tend to under-represent contrasts. They should not be the only basis for impact determination. The visual contrast description should also be considered, accounting also for the dynamic visual experience of real projects in real landscapes.

Ultimately, visual impact determination relies to some extent on various professional judgments by the analyst, who must use imperfect tools and imprecise terminology to assign impact levels based on inherently complex phenomena and variable human responses. This should be considered when evaluating the impact determinations.

A determination of the magnitude of impacts usually will incorporate required mitigation. In other words, if the developer is required or has committed to incorporating specific mitigation measures to avoid or reduce visual impacts from the project, the beneficial effects of the mitigation are included in the impact assessment. This would normally have the effect of reducing the magnitude of impacts ascribed to the facility. However, optional mitigation should not be incorporated into the impact assessment because there is no guarantee that it will be implemented if and when the project is built. Mitigation of visual impacts is discussed further in Section 4.2.11.

4.2.10 Impacts of Alternatives, Cumulative Impacts, and Other Types of Visual Impacts

NEPA requires that alternatives to the proposed action also be considered in an EIS. A "No Action" alternative that examines impacts associated with not building the proposed project is always included, but there may be one or even several action alternatives that are also examined. The alternatives may include modifications to the project layout, a change in size of the project (e.g., fewer or more wind turbines), or changes to the technology employed (e.g., "wet" cooling versus "dry" cooling for solar thermal power plants). Transmission projects almost always involve multiple alternative routes, and, in general, the treatment of alternatives makes up a bigger portion of the VIA for a typical transmission project than for typical wind or solar projects. In practice, transmission route alternatives are more likely to be viable options for the project, whereas the "preferred alternative" is usually what is selected for wind and solar projects because that is what the developer proposes to build.

Most EISs include *Comparison of Alternatives* sections or chapters that summarize and compare the impacts of the alternatives examined in the EIS. These sections/chapters may be very helpful for evaluators. In many EISs, these summary chapters may precede the *Environmental Consequences* chapter.

> **TIP**
>
> *Indirect visual impacts are usually much less significant than the direct visual impacts of a project, and many VIAs do not address indirect visual impacts at all. Indirect cumulative impacts may be particularly important because the presence of multiple facilities may have subtle effects not apparent on an individual project basis.*

<u>Description of Indirect Impacts</u>

Indirect visual impacts should also be discussed in the VIA. Indirect impacts are defined in various ways, but they usually are defined to mean impacts that occur away from the project location, in a spatial and/or temporal sense. For example, if the construction of a large renewable energy facility brings a large number of workers to a nearby community and these persons live in temporary housing such as trailer homes, the addition of trailer homes to the landscape may cause indirect visual impacts, because the effects occur away from the project site and do not arise from the project itself.

Indirect visual impacts are generally subtle, sometimes temporary, and usually are much less significant than the direct visual impacts of a project, that is, the visual presence of the project itself. Many VIAs do not address indirect visual impacts at all. NPS staff should consider whether a project is likely to cause indirect visual impacts and request that indirect impacts be included in the analysis if necessary. Indirect visual impacts may be particularly important in the context of cumulative visual impacts, as the presence of multiple facilities in an area may have subtle effects over time that are not apparent or may be insignificant on an individual project basis.

Description of Cumulative Impacts

Cumulative visual impacts are the combined effects from the proposed project with other past, present, or likely future actions (typically development activities), whether of the same type as the proposed project or not, within a certain prescribed distance from the proposed project. The *Cumulative Impacts* section should clearly identify and describe past, present, and likely future development projects or other actions that will contribute to cumulative impacts. In the case of future projects, they may be known if they are in the permitting process. Otherwise, some kind of sound assumption and rationale should be identified for estimating the nature and number of future projects, such as an estimated level of development in a solar energy zone, or an estimated number of projects in a known high wind resource area.

TIP

Despite the potentially significant contribution of cumulative visual impacts to the overall impacts associated with renewable energy development, they are often poorly addressed in VIAs. NPS staff should examine the cumulative impact assessment carefully to ensure that it uses an appropriate radius of analysis and includes all relevant existing developments. The cumulative impacts should also make a reasonable attempt to forecast future actions that could affect the landscape and account for future generations of viewers.

The requirement to assess cumulative impacts arises from the recognition that while the impact of a single project considered by itself may be small, it must also be considered as an incremental addition to a variety of other activities that may be affecting the landscape around the project. These activities could include the building of similar renewable energy facilities, but also any other type of facility, or even actions that do not involve facilities at all, such as conversion of lands to agricultural or other uses. Cumulative visual impacts could include direct physical effects on the landscape or changes to the character of the landscape, such as changing a landscape that is essentially natural appearing to one that is industrial in character. The section should also include effects on future generations of viewers who would be the primary viewers of the altered landscape.

Cumulative visual impacts can occur:

- Where multiple facilities are seen within the same view without the viewer turning his/her head (the facilities may be juxtaposed so that one is seen “through” the other; see Figures 4.2-33 and 4.2-34);
- Where multiple facilities can be seen successively if the viewer turns his/her head; or
- Where multiple facilities are viewed in succession as the viewer moves through the landscape (e.g., driving on highways, hiking trails, or boating on rivers). In this case, multiple facilities can impact the viewing experience for moving viewers even if the facilities are not visible from a single common viewpoint.

Cumulative visual impacts are particularly important with respect to utility-scale renewable energy facilities because the facilities’ high visibility over long distances increases the chances that multiple facilities are in view at the same time or in succession for moving viewers (e.g., persons driving on highways, hiking trails, or boating on rivers). The widespread rapid development of both renewable and fossil energy resources involves new or upgraded electric transmission, pipelines, roads, communications towers, increased traffic, dust, and light sources at night, which taken together have the potential for transforming landscape character over large areas in a relatively short timeframe (see Figures 4.2-33, 4.2-34, and 4.2-35).

Description of Irreversible or Irretrievable Commitments of Visual Resources
A resource commitment is considered irreversible when direct and indirect impacts from its use limit future use options. Irreversible commitments apply primarily to nonrenewable resources, such as cultural resources, and also to those resources that are renewable only over long periods of time, such as soil productivity or forest health. A resource commitment is considered irretrievable when the use or consumption of the resource is neither renewable nor recoverable for future use. Irretrievable commitments apply to loss of production, harvest, or use of natural resources.

Visual impacts from renewable energy projects may be reversible; that is, when a project is decommissioned and the project elements removed, the visual environment may be restored, in some cases, in nearly the same condition as prior to development of the project. However, in other cases, the visual resource may be permanently affected; for example, if major earthmoving occurs in the course of a project, or as is the case in some desert environments, recovery of natural vegetation is impossible or nearly so. In these cases, the loss of visual amenity may be considered irreversible, and if this is the case for a particular proposed project, it should be discussed in the VIA.

4.2.11 Mitigation

Visual impact mitigation measures are methods or actions that will reduce potential adverse visual impacts from facility development. Visual impact mitigation measures can include practices to avoid, minimize, rectify, or compensate for adverse visual impacts. The large-scale and industrial character of wind, solar, and transmission projects can make them visible for long distances, and many of the mitigation measures developed over time for smaller-scale projects, such as oil and gas development, may not be effective at reducing visual impacts for much larger renewable energy facilities.

Figure 4.2-33. Multiple Transmission Lines And A Wind Energy Facility Stretch Across Much Of This View In A Prairie Landscape, Creating Large Cumulative Visual Impacts (Credit: Argonne National Laboratory)

Figure 4.2-34. Juxtaposition Of Two Offshore Wind Facilities In The United Kingdom Creating Cumulative Impacts (Differing tower structures add to the cumulative effect.) (Credit: Argonne National Laboratory)

Figure 4.2-35. Solar Facilities, A Natural Gas Plant, Substations, Communication Towers, And Skyglow From A Major City Combine To Create Large Cumulative Night-Sky Impacts (Credit: Argonne National Laboratory)

Mitigation measures are an important part of a VIA because they will identify if and how the impacts of a project can be reduced. The VIA is a technical resource report that informs the NEPA analysis, and including effective mitigation measures in the early stages of a project may influence the project design to avoid or minimize potentially large visual impacts. Council on Environmental Quality (CEQ) regulations (CEQ 1978) specify that mitigation measures should be presented in the analysis of alternatives; however, in many EISs, mitigation measures are presented in the *Environmental Consequences* chapter.

To assist in addressing the challenges of reducing the impacts of utility-scale onshore wind and solar energy projects, the BLM has developed a guide entitled *Best Management Practices for Reducing Visual Impacts of Renewable Energy Facilities* (hereafter referred to as the *BMP Guide*) (BLM 2013). The *BMP Guide* contains good design practices and mitigation measures that can be implemented at all stages of a project. Except for the mitigation measures for offshore wind energy projects, the best management practices (BMPs) and mitigation measures included in this section are primarily summarized from the *BMP Guide*, which should serve as a reference for detailed descriptions of the BMPs and mitigation measures. The BMPs and mitigation measures in the *BMP Guide* were developed for application in western landscapes; most of them, however, would apply in other parts of the country.

Visual Impact Mitigation Content—What Should Be Included

A VIA will not only include the approaches to mitigate the visual impacts of a project but will also clearly identify whether the mitigation is included in the design of the project (and thus assumed to be implemented for purposes of the impact analysis) or whether the mitigation is suggested to further reduce potential impacts. The appropriate land management agency and the project developers should be encouraged to include mitigation from the earliest stages of planning through final project design.

> **TIP**
>
> *The BLM visual impact mitigation guide is a useful resource for NPS staff. Although it is limited to onshore wind, solar, and geothermal facilities in western landscapes, many of the mitigation measures in it can apply regardless of the setting. The numbering of each mitigation measure in the checklists in this document corresponds directly to those in the BMP Guide for ease of reference.*

Good design practices, such as adjusting project siting or careful selection of materials to reduce visual contrasts with the surrounding landscape, help to avoid visual impacts and should be raised at the pre-application meeting discussed on page 9 of this document. These good design practices must be considered as early as possible in the project siting and design process; a project that avoids impacts where possible and incorporates mitigation measures into the project siting and design often reduces the need for costly and often less effective mitigation measures to reduce impacts after the fact.

The sections below provide a **brief summary** of BMPs and mitigation measures (primarily drawn from the *BMP Guide*) that are specific to each technology as well as measures that are common to all types of projects. Mitigation measures for “common elements”—those facility components and actions common to all renewable facilities, such as roads, structures, or vegetation management—are summarized by topic area to be consistent with the BLM mitigation measures.

Appendix C contains a checklist of the mitigation measures that can be used as part of the visual assessment review to identify the best mitigation measures and the appropriate phase of the project in which they can be applied. The checklist is not meant to be prescriptive; not all measures can or should be applied to all projects in all situations. Rather, the most appropriate mitigation measures should be used on a project-by-project basis, considering the existing visual setting, landscape type, and other factors.

Common Elements

Mitigation Planning

The mitigation measures at this stage address planning issues concerning visual impact analysis and mitigation, including making sure the right qualified parties conduct the work using appropriate methods and that necessary planning documents, such as reclamation plans and monitoring, are in place. The measures also suggest pre-construction meetings and discussion of visual mitigation objectives with the equipment operators and construction personnel responsible for implementing mitigation, in order to ensure they understand the intent of the measures. An additional measure is the use of off-site mitigation; that is, the correction or remediation of visual impacts resulting from activities or conditions not connected to the project and occurring at a different location.

> **TIP**
>
> *Many VIAs list mitigation measures that* ***could*** *be undertaken to reduce visual impacts from the proposed project, but they may not necessarily be required. NPS staff should ascertain whether the mitigation described in the VIA is required or potential. In some cases, NPS may wish to request that optional mitigation measures become requirements.*

Siting and Design

These mitigation measures help ensure that facilities and their components are sited to avoid or reduce impacts on visually sensitive areas. Measures include siting facilities away from prominent viewsheds or features; placing facilities in previously disturbed landscapes; designing elements to repeat the form, line, color, and texture of the existing landscape; and minimizing cut and fill. Additional measures recommend co-locating facilities in existing ROWs or transmission line corridors, and locating them along natural lines in the landscape, away from valley bottoms and ridge lines.

Structure Design and Materials Selection

These mitigation measures address the selection and design of structures, landforms, and other materials to blend with the existing landscape setting. Measures include using low-profile structures, using custom designed features in key areas, minimizing paved surfaces, and using rounded cut slopes.

Materials Surface Treatment

The mitigation measures for surface treatments address selection of appropriate colors and surface treatments for structures to reduce color contrast with the surrounding natural environment. Specific mitigation measures include selecting treatments to repeat the form, line, color, and texture of the surrounding landscape, using non-reflective coatings, treating exposed rock surfaces with coloring agents or chemicals that accelerate the natural aging process, and using camouflage and/or specialized disguise strategies for close-up views within sensitive viewsheds.

Lighting
The mitigation measures to help ensure that projects minimize impacts on night skies through proper lighting design and usage include restricting lighting to the minimum amount required for safe operation of the facility, using full cut-off light fixtures, directing lighting to minimize off-site light spill, using amber lighting rather than bluish-white lighting, and using portable lighting for nighttime maintenance activities. An additional measure includes using AVWS technology for aviation hazard lighting so that lighting is only activated when aircraft are present, if and when the AVWS technology is approved by the FAA. (The use of this technology is currently undergoing FAA review).

Avoiding Disturbance
These mitigation measures help to avoid or minimize land and other types of disturbance. Measures include avoiding unnecessary roads, pre-defining construction areas, avoiding permanently marking survey limits or other project areas, and driving overland rather than re-contouring in some settings. Additional measures also suggest educating construction personnel by providing maps of avoidance areas and using penalty clauses to protect high-value landscape features.

Soils and Erosion Management
These mitigation measures include implementing dust and wind erosion as well as sediment control and soil erosion measures. Also included are measures to use temporary stabilization methods, as needed, and to strip, stockpile, and stabilize topsoil for future re-spreading and reclamation.

Vegetation Management
The mitigation measures concerning vegetation management include preparation of a reclamation plan, protecting existing vegetation through the use of retaining walls, fences, or other features, and designing vegetation clearings to mimic natural openings for a particular vegetation community. To promote successful re-vegetation, measures include using pitting and vertical mulching techniques, re-vegetating using salvaged or material transplanted from cleared areas, and monitoring and maintaining re-vegetation areas until they are self-sustaining.

Reclamation
These mitigation measures promote successful interim and long-term reclamation through good soil contouring practices, site preparation to promote re-vegetation, and removal of structures and surface treatments. Other measures include salvaging and replacing rock, brush, and woody debris; sculpting bedrock landforms; removing or burying gravel; and other surface treatments.

"Good Housekeeping"
The last section of mitigation measures common to all projects addresses measures to keep the site clean and orderly during construction, operations, and decommissioning. Measures include using tire washes and vehicle track pads, prohibiting on-site burning, removing slash piles, removing stakes

and flagging when no longer needed, and maintaining a clean and orderly project site, which helps promote a serious and professional image to outside observers.

Onshore Wind

Mitigation measures for onshore wind projects are generally directed at enhancing the visual character of the projects, since the turbines are generally very visible in the landscape. Measures such as clustering turbines, arranging them in orderly layouts, using fewer and larger turbines, and using a single turbine design for all turbines in a facility give the project a sense of more orderly design. When possible, using topography to screen turbines from view and relocating turbines to limit visibility can also reduce overall visual impacts. Other mitigation measures, such as keeping the turbines in good repair, using non-reflective coatings on surfaces, and keeping the towers and nacelles clean, can help a project attract less visual attention.

Offshore Wind

Mitigation measures for offshore wind projects are generally similar to those for onshore wind projects. However, they also include measures such as siting developments so that intervening headlands screen views from sensitive landscapes/seascapes, siting facilities so that they are not framed by landforms in views from highly sensitive inland scenic vistas or other sensitive areas, and designing the facility to minimize the horizontal spread of the layout from shore.

Solar

For solar projects preparing a glint and glare assessment, siting, operating, and screening the facility to minimize off-site glare are key measures to minimize visual impacts, especially for parabolic trough and power tower facilities. Additional measures, such as using color-treated support structures and avoiding complete removal of vegetation in the solar array area, also can help reduce visual impacts. Use of dry-cooling technology for parabolic trough and power tower solar power facilities can help reduce the visual distraction of the color and motion associated with water vapor plumes.

Electric Transmission

The transmission lines associated with renewable energy facilities to transmit electricity from the facilities to the electrical grid (frequently referred to as *generation-tie* or *gen-tie lines*) often extend over many miles, but the visual impacts can vary widely from one location to another. In addition to utilizing the common element mitigation measures such as reducing disturbance (particularly through ROW vegetation management) and using good siting design (particularly for access roads), choosing the appropriate tower type (monopoles or lattice towers) for particular landscape settings, or even color treating towers, can reduce the visual impacts. Using air transportation to erect towers minimizes disturbances and helps to reduce impacts, but it is a measure that is usually only employed in highly sensitive landscapes because of the expense.

4.2.12 Compliance with Applicable LORS and Agency Policies

A determination of the mitigated project's compliance with applicable LORS and agency visual resource management objectives (typically found in agency planning/policy documents; e.g., a BLM Resource Management Plan or a USFS Forest Plan) should be made in the VIA or EIS. The determination is made by comparing the expected impacts of the project—with the required mitigation—to the allowable impacts specified in the LORS or agency management objective. In some cases, mitigation measures may be sufficient to reduce impacts to an acceptable level; in other cases, despite mitigation, the project's impacts may exceed the allowable standard.

> ***TIP***
>
> *A VIA/EIS should also indicate consistency with NPS policies and management objectives of NPS units or other special status areas under NPS management within the viewshed of the proposed project.*

Compliance and non-compliance with applicable LORS and agency management objectives (e.g., BLM's VRM classes) should be systematically identified and described. Where mitigation is required for LORS or agency management objective compliance, the specific applicable LORS or management objective should be cited, the portions or aspects of the project that are out of compliance should be noted, the nature of the non-compliance should be described, the required mitigation measures should be described, and how the mitigation measure will bring the project into compliance with the LORS or management objective should be discussed. Where mitigation will be insufficient for compliance with LORS or agency management objectives, similarly detailed documentation should be provided in the VIA/EIS.

5. Interpreting and Evaluating Visual Impact Simulations

This chapter provides guidance on evaluating the quality of visual impact simulations. Simulations are an important tool used by visual impact analysts for impact assessment and for stakeholder communication. Guidelines for producing and presenting simulations are provided that form a useful basis for NPS staff to evaluate the quality of the simulations. Also included is a discussion of photomontages, the main visual impact simulation technique used in VIAs. The use of animations is also discussed. Important limitations and common problems associated with the production and presentation of simulations are presented. Other types of visual simulations are briefly discussed.

5.1 Introduction

In the context of professionally prepared VIAs, visual simulations are visualizations (typically computer-generated) of the proposed project and surrounding landscape that are used to depict the overall appearance of a proposed project after it is operational. In ideal VIAs, spatially accurate and realistic simulations are used to depict views of the proposed project from selected KOPs. Simulations are an important component of VIAs for renewable energy projects; their primary use is to help the impact analyst assess the visual contrasts created by the project and to help stakeholders visualize and respond to development proposals. Simulations can also be useful in the project design process, as a tool to assess the potential impacts associated with particular project siting strategies. They are also used to evaluate the effectiveness of mitigation measures and BMPs to avoid or reduce impacts.

Although simulations are not technically required to be used in VIAs, it is common practice to use them in impact assessments for utility-scale renewable energy projects, which typically involve large visual impacts. Visual simulations are not the same as "real life views" but are useful tools to assist in the VIA process (NZILA Education Foundation 2010; Landscape Institute 2011). Although simulations have important limitations, it may be difficult to understand and assess the potential visual impacts of a proposed project without them.

The development of high-quality simulations and their proper use for a VIA is a complex technical undertaking. While the technology to create realistic simulations constantly improves, the process is subject to errors and inaccuracies that may have important effects on the quality of the finished product. Guidelines for the development and presentation of visual simulations are presented in Section 5.2. It is important for NPS staff to have a basic understanding of the visual impact simulation development process, the limitations of visual simulations, and commonly observed sources of errors and inaccuracies in order to properly interpret and evaluate visual simulations. A summary of the development process for photomontages, currently the main method for producing simulations for VIAs, is presented in Section 5.3, and the

> **TIP**
>
> *Simulations are an important tool for evaluating visual contrast and identifying appropriate mitigation. NPS should request that simulations be included for any project for which there is a reasonable chance of non-negligible impacts on NPS–resources from development on lands or waters owned or administered by other parties.*

use of animations for simulations is discussed in Section 5.4. Even the best simulations have important limitations in terms of accuracy and realism. These limitations are discussed in Section 5.5. Sources of error and inaccuracy in simulations are presented in Section 5.6. Other types of simulations used to supplement photomontages are discussed in Section 5.7.

In a NEPA VIA document, the description of the use of simulations is often contained in the *Environmental Consequences* section (see Section 4.2).

5.1.1 Responsibility for Simulation Preparation

Preparation of simulations is normally the responsibility of the project proponent; however, they are usually prepared by the VIA team or another contractor that specializes in preparing simulations. The preparation of high-quality simulations is a specialized skill that should be undertaken only by trained, experienced professionals with adequate resources and time to develop a high-quality product.

5.1.2 Types of Simulations

Although there are many types of visual simulations, the “workhorse” of VIAs is the photomontage (also referred to as a photosimulation), a still image of a highly realistic three-dimensional (3D) model of the proposed facility superimposed onto a photograph of the existing landscape. Other types of simulations include computer-generated schematic wireframe drawings, completely synthetic landscape renderings that do not involve the use of photographs, sketch graphics, and animations. These types of simulations may be very useful for depicting particular aspects of a proposed facility or for illustrative purposes, but they are generally used to supplement photomontages in VIAs. This discussion will focus primarily on photomontages, because they are the most commonly used format for VIAs. Because movement is an important aspect of the visual experience of wind energy facilities, and to a lesser extent solar facilities, the use of animation in simulations will also be discussed.

> ***TIP***
>
> *For controversial projects, visual simulations sometimes are prepared by project* ***opponents****. They may be of poor quality, or misleading in showing impacts, and should not be used for impact determination unless properly prepared by trained personnel.*

5.2 Guidelines for Producing and Evaluating Simulations

The following guidelines present best practices for simulation preparation and use in VIAs. These guidelines are summarized in a Visual Simulation Checklist in Appendix C.

> ***TIP***
>
> *Use the visual simulation checklist in Appendix C to quickly evaluate the quality and completeness of visual simulations in a VIA.*

5.2.1 General Principles

The following general principles for producing and presenting visual simulations are adapted from Sheppard (2005) and serve as high-level guidelines for visual impact simulation evaluation:

- **Simulations should be spatially accurate and realistic**. Simulations should simulate the actual or expected appearance of the landscape and project as closely as possible, according to the data available at the time.
- **Simulations should be representative.** Simulations should represent the important and typical range of views which would be experienced with the actual project and provide viewers with a range of viewing conditions, including typical worst-case scenarios.
- **Simulations should be visually clear.** Simulations should be properly prepared and displayed, such that project components and the surrounding landscape are depicted clearly and with sufficient detail to serve as a sound basis for impact assessment.
- **Simulations should be engaging without entertaining.** Simulations should engage and hold the interest of viewers, while avoiding the use of presentation techniques that are entertaining or impressive without adding significant information value.
- Simulation methodology should be defensible and documented. The methodology used to produce simulations should follow procedures that will withstand scientific scrutiny, are consistently followed, and are thoroughly documented. The documentation should include clear descriptions of known and potential sources of error and uncertainty.

A VIA that includes simulations that do not adhere to the above criteria is seriously deficient. NPS staff should note any important apparent deficiencies concerning simulations in VIAs, discuss them with the parties responsible for preparing/approving the VIA, and request that they be corrected prior to completing the impact assessment.

> **TIP**
>
> *A VIA that includes poor simulations is seriously deficient, and NPS staff should note any important apparent deficiencies and request that they be corrected prior to completing the impact assessment.*

5.2.2 Single-frame vs. Panoramic Simulations

Simulations may be single-frame or panoramic, or both. The choice should be determined on a case-by-case basis. Simulations should show enough of the surrounding landscape to show the project in the appropriate spatial context. In most cases, the presentation of both a single-frame and panoramic image for each simulated view is greatly preferable to showing either one alone. Single-frame images may be needed to show adequate details of the objects in the simulation to depict it realistically, but they may not show as much of the facility as would be seen in “real world” views. Also, a single-frame image may not show enough of the surrounding landscape to portray the visual context properly, or to show the scale of the project in relation to its surroundings (Landscape Institute 2011). Panoramic images show more of the project and its surroundings; this is particularly important for the depiction of renewable energy facilities in open landscapes, as the facilities tend to be very large. The human horizontal field of view is approximately 124° (NZILA Education Foundation 2010), and this entire field of view can be shown in a panoramic image. However, in some cases, panoramic images may lack details that would be visible in reality, especially when they are reproduced at relatively small sizes, which is common in practice. Showing both types of images for each simulated view allows proper depiction of facility details, while showing the facility in the proper visual context and better depicting its scale in relationship to its surroundings.

5.2.3 Selecting KOPs, Season, Time of Day, and Lighting Conditions for Simulations

The selection of appropriate KOPs and the season, time of day, and lighting conditions for simulations requires careful consideration of a number of factors. Typically, simulations should capture seasons and time periods of highest visitor use at KOPs, and under sunny conditions with good visibility for the specified location. At a minimum, simulations should depict conditions with the greatest reasonable visual impact scenario for KOPs. For example, if a solar project is expected to produce glare (annoyingly bright reflections) at KOPs, at least some of the simulations for the project should depict the glare as it would be seen from KOPs. Similarly, simulations of wind facilities should not be limited to depictions of the facility with the turbine blades parallel to the line of sight, such that they show the least amount of visible surface area in the simulations. Where projects are expected to have substantial night-sky impacts, these impacts should be portrayed in night-sky impact simulations.

In more sensitive situations, it may be desirable to depict additional seasons, times of day, and lighting conditions in simulations; however, high-quality simulations are expensive and time-consuming to produce. A reasonable balance must be achieved between producing enough simulations to show the range of impacts from all important KOPs and other typical viewing situations, and expending excessive money and time either producing or redoing simulations that do not add significantly to an understanding of the impacts. For example, where potential KOPs are closely spaced and have very similar views of the project, it may be preferable to develop one representative simulation rather than developing multiple simulations that would show essentially the same view and visual contrasts.

5.2.4 Preparing Accurate and Realistic Simulations

Simulations should be based on accurate project design specifications and on accurate spatial information (particularly elevation data), and must account for earth curvature and screening vegetation and structures. Simulations should be spatially accurate; they should show all of the project elements and other project development effects that would be visible, at the correct size and location, and in the correct visual perspective. They should be realistic (i.e., they should look like the facility would actually look when built, as seen from the relevant KOP). They should be illuminated, colored, and shaded realistically, with cast shadows that are depicted accurately and realistically. Any known errors or uncertainties in accuracy or realism should be clearly stated so that viewer expectations are appropriate.

5.2.5 Simulation Image Size and Viewing Distance

Simulations should be reproduced at a size large enough to be comfortably viewed from the appropriate specified viewing distance that accurately depicts the apparent size of the facility as it would be seen in the real landscape. For printed simulations, foldouts should be used, if needed, to enlarge the simulation so that adequate detail can be seen while preserving a large horizontal field of view. The proper viewing distance for the simulation (the distance that the simulation should be held from the viewer's eye) at its intended reproduction size should be specified. If panoramic images are shown at large sizes in public meetings or similar settings, they should be mounted on curved surfaces so that all parts of the image can be viewed at the correct viewing distance. If this is not possible, they should be displayed in a space that allows viewers to move to a position directly in front of the portion of the image they are viewing.

5.2.6 Simulation Output Quality

High-quality prints are usually desirable for impact assessment purposes and for public information presentations. Professional printing services should be used whenever possible. Night-sky impact simulations should preferably be projected using a high-resolution projector (SXGA+ or better) and a projection screen (not a wall) in a darkened room to simulate the real night-sky viewing situation to the extent possible. Correct color balance is also important, and color correction hardware should be used if possible. Higher end color correction hardware will take ambient light readings to assist in determining the correct brightness for screen display.

5.2.7 Simulation Presentation Lighting

Simulations should be presented under adequate lighting to show fine details in all parts of the simulation. Lighting should not be so bright, however, as to cast obscuring glare onto the image. Night-sky impact simulations present special problems for display, because much of the image is very dark, and the lights visible within the simulation may not be bright. Viewing night-sky impact simulations in a well-lit room makes it very difficult to judge accurately the effect of the lights on dark night skies, and the lights depicted in the simulation may be hard to see at all. To the extent possible, night-sky impact simulations should be projected in a room that is totally dark.

5.2.8 Labeling and Supplementary Information

Supplementary information should be provided to indicate the project, KOP location, and alternative depicted in the simulation. This information should be provided on a separate sheet that accompanies the simulation and is always displayed with the simulation. Simulations should include a variety of supplementary information, including:

- Geographic coordinates and elevation for the camera/KOP location;
- Date and time of the photograph;
- View direction and camera height;
- Weather conditions;
- Lighting condition (frontlit, backlit, sidelit) and solar azimuth/elevation;
- Camera and lens make and model;
- Focal length used for photograph (for film single-lens reflex [SLR] cameras) or 35-mm equivalent focal length for digital SLR cameras;
- Horizontal and vertical width of field depicted in the simulation;

- Distance to nearest and farthest visible portions of facility (e.g., the nearest and farthest visible wind turbines);
- Proper viewing distance for the simulation in the presented format; and
- An inset or supplementary map (with a legend) that shows the location of the KOP, the facility boundary and major components, nearby features such as roads and populated places, and that depicts graphically the horizontal field of view shown in the simulation.

5.2.9 Simulation Methodology Documentation

In addition to the simulation-specific supplementary information discussed above, the methods used to develop simulations should be thoroughly and clearly described in the VIA. Documentation should describe the rationale for KOP selection and KOPs eliminated from consideration, parties identifying KOPs, and those preparing the simulations, photographic and simulation production methods and equipment, as well as measures taken to ensure simulation accuracy. Base photographs, field logs, and other intermediate products such as wireframes should be available on demand.

5.3 Photomontage Production Summary

Photomontages developed for modern VIAs use specialized computer software to superimpose a computer-generated image of the proposed project facility onto a digital photograph of an existing view of the proposed project site. The photograph of the existing landscape (referred to as a base photograph) is taken from a desired viewpoint (generally a KOP) and captures the project site and the surrounding landscape. The image of the facility is derived from a spatially accurate and realistically rendered 3D model of the facility that is placed in the base photograph so that it appears at exactly the same position as it would be seen from the KOP, is the same size as it would be seen from the KOP, and in the same visual perspective.

The typical process used for preparation of high-quality photomontages for use in VIAs can be summarized as follows:

- After KOPs for the proposed project have been identified, one or more KOPs are selected for use in preparing simulations.
- Using high-quality digital cameras and lenses, and under carefully controlled conditions, the project location is photographed from each KOP for which a simulation will be prepared. The precise locations of the camera, the point at which the camera is aimed, and other control points in the surrounding landscape visible within the photo are recorded, as is the lens focal length and other photo data. The date and time are also recorded, in order to calculate the position of the sun in the sky. A photograph of the project area for an offshore wind facility used as the base photograph for a photomontage is shown in Figure 5.3-1. **[Note: Because of the scale and orientation of Figures 5.3-1 through 5.3-3, they are located at the end of this chapter.]**
- Using appropriate visualization software, a spatially accurate 3D wireframe model of the project is built and placed on a spatially accurate 3D model of the project landscape (the *terrain model*), derived from elevation data for the earth's surface.

- A “view” of the 3D model is set up in the software using the identical lens focal length, camera, and project coordinates recorded for the photograph, so that the model is shown in the same location, at the same size, and in the same visual perspective as the built project would be seen from the KOP.
- The wireframe terrain model and the 3D model are superimposed precisely onto the photograph using the control points to assist with accurate alignment of the terrain model and the photograph. The 3D model is thus shown in the correct location, at the correct size and aspect, and in the correct visual perspective in the photograph. Minor adjustments are often necessary because of imperfections in the elevation and/or project data. Figure 5.3-2 shows appropriately scaled 3D wireframe models of offshore wind turbines accurately superimposed onto the base photograph shown in Figure 5.3-1.
- The terrain model is stripped away, and the model is *rendered*, that is, its surfaces are colored and shaded in the computer program to match the properties of the facility elements of the real project. The sun position data, as well as information on cloud cover and weather patterns recorded at the time the photograph was taken, are used by the visualization software to calculate lightness and darkness of shading and the correct positioning of shadows cast by model elements. Minor adjustments to the rendering may be made using photo editing software, typically to achieve greater realism (e.g., blending of sharp edges to mimic the softening of outlines with distance). Image editing tasks may also include removal of trees and other structures in the existing landscape, re-insertion of foreground elements that would be seen in front of the project, adjustments to landforms, and other edits related to changes to the landscape associated with project construction. Figure 5.3-3 shows a spatially accurate and realistic simulation of an offshore wind facility.
- The simulations are prepared for presentation in one or more output formats. Preparation includes preparation of supplementary information for the simulation to aid simulation viewers in interpretation of the simulation. This supplementary information should be provided on a separate sheet that accompanies the simulation (see Figure 5.3-4). Providing the supplementary information separately avoids showing distracting graphical elements when the simulation is presented, and affords as much room as possible to show the project and surrounding landscape in the simulation. Output formats typically include large-format, high-resolution prints; they may also include digital files for computer projection and smaller format prints for use in reports and other communication pieces.
- If the simulation is a panoramic simulation (see Section 5.2.2), additional steps are needed that involve taking additional photos to capture a larger portion of the landscape, the digital “stitching” of multiple photos to create the panoramic view, and correction of distortions that may be introduced into the stitching process.

Simulation

010 Long Point Camps

Early Morning

Siemens SWT-3.6-107

10 nm

GENERAL INFORMATION

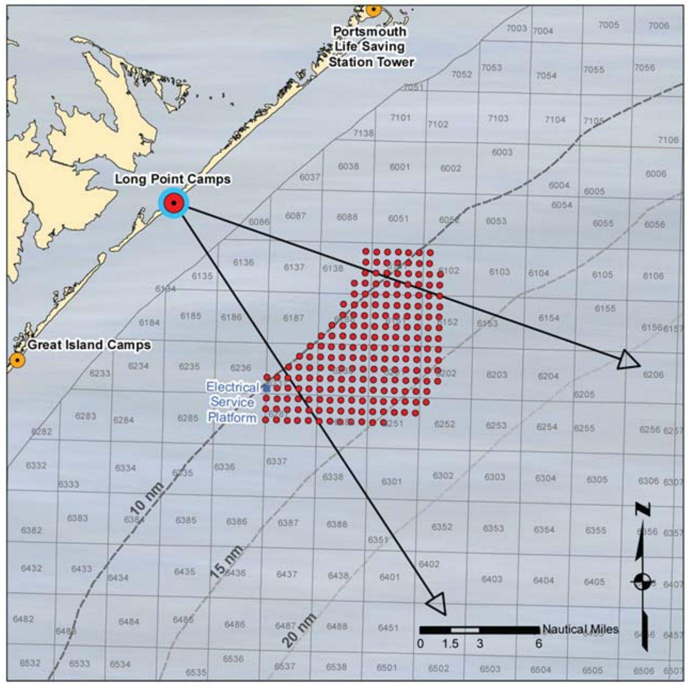
Base Photograph
Photo Name: LPM_0170-UV2
Date: June 3, 2012
Time: 6:17 AM
GPS Coordinates[1]: lat 34.898961°, long -76.255103°
Viewpoint Elevation: 11’

Sun and Weather
Sun Angle/Azimuth: 74°
Sun Elevation: 16°
Lighting Angle: Back lit
Weather Conditions: Sunny
Visibility[2] : 10 mi
Wave Height: 1 - 2’
Period: 7 - 8 sec.

Camera
Camera Make/Model: Nikon D7000
Sensor Dimensions: 23.6 mm X 15.6 mm
Lens Make/Model: Nikkor DX AF-S 35 mm
Lens Focal Length: 35 mm
35 mm Equivalent Focal Length: 52.5 mm
Horizontal and Vertical Angles of View:
37.3° wide and 25.3° high
Camera Height: 1.5 m (5’)
Camera Azimuth[3] : 117°

Wind Turbine Information
Number: 200
Make and Model: Siemens SWT-3.6-107
Height/Dimensions:
Support Structure/Monopile Ht.: 13 m (43’)
Hub Ht. (above Monopile): 80 m (262’)
Rotor Diameter: 107 m (351’)
Total Height to Tip of Blade: 147 m (481’)
Service Platform: A bldg. 50’H X 100’W X 200’ L elevated 50’ above the water

CONTEXT MAP



VIEWING INSTRUCTIONS

The simulation is properly printed on an 11” X 17” sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5” from the eye, or at a distance of approximately twice the image height.

NOTES

- The image was taken with a UV filter.
- Refraction Coefficient[4] (k) = .075

PANORAMA

Simulation location within the panorama view (190° X 60°) from the Long Point Camps site

T. J. Boyle Associates
landscape architects • planning consultants

Figure 5.3-4. appropriate supplementary documentation for a simulation provided separately from the simulation (Credit: BOEM)

5.4 Animations

If desired, with the use of appropriate software and techniques, a sequence of still images (e.g., photomontages) can be combined to create an animation that shows movement of either project components or the viewer, or change in the appearance of the project and surrounding landscape over time. For example, animations are particularly effective for showing wind turbine blade motion, the synchronized flashing of wind turbine aviation obstruction lighting at night, changes in position and reflectivity of solar collectors/reflectors over the course of a day, and changes in lighting conditions as the sun rises and sets or clouds pass in front of the sun. Animations can also depict the change in the viewed landscape and visual contrasts as the viewer moves (e.g., while hiking a trail, floating on a river, or driving a scenic byway). Animations used for visual simulations typically run from a few dozen seconds to a few minutes in length, and they are shown in a variety of digital movie formats on computer monitors or as larger projected images.

The visual characteristics of renewable energy facilities are such that the viewing experience is dynamic. The appearance of wind and solar facilities, in particular, may change dramatically in the course of a day. Because change over time and movement of both the viewer and objects in the landscape are both inherent and essential aspects of the human visual experience, the use of animation in visual impact simulation can increase the realism of the simulations. It is particularly useful for applications where movement is an important characteristic of either the project or the viewing experience.

Despite the advantages of animations for showing movement and change over time, still-image photomontages currently are much more widely employed for visual impact simulation than animations. Animated photomontage sequences are more expensive, time consuming, and difficult to create than still-image photomontages, and the output resolution of the animations is not as high as the resolution of high-quality digital images and prints. Also, the technology needed to display animations limits their use for some applications; such as, use in the field to compare the simulation with the real view of the landscape. Even with these limitations, the use of animations for visual impact simulation is increasing and may be appropriate for particularly sensitive or important simulations.

5.5 Limitations of Simulations

Although high-quality visual simulations are a useful tool for assessing visual contrast, for a variety of technical reasons, even when properly prepared, simulations are limited in their ability to realistically portray the full range of the visual experience of utility-scale renewable energy facilities, particularly wind and solar facilities. It must be kept in mind that they are based on photographs or videos, and, ultimately, what they simulate is a photograph or a video of the proposed project, not the actual visual experience a viewer would have in a real landscape looking at the real project (NZILA Education Foundation 2010; Scottish Natural Heritage 2006). Because of limitations inherent in the photographic medium, simulations are approximations of what the project would look like and are not the same as “being there.” Indeed, observations made by Benson (2005) suggest that simulations of proposed wind farms in VIAs often underestimated the impacts compared with field observations of the built projects, in part, because “the windfarm often looked nearer, more visible, and more conspicuous than the photomontage predicted." The following sections discuss some of the major limitations of visual simulations based on photography, including photomontages.

5.5.1 Loss of Dynamic Visual Experience

Although everyone is familiar with photographs and accepts them as a close approximation of visual reality, still photographs are static, limited representations of the view from one location at an instant in time, and the view is chosen by the simulation creator, not the viewer. In reality, the human visual experience is dynamic, changing constantly as the viewer turns his/her head or moves through the landscape as he/she desires. The visual environment changes constantly too, as the sun's position changes in the course of the day and as clouds pass overhead. And, of course, elements of the project itself may move or change their appearance dramatically over time. The synchronized motion of wind turbine blades is a very important part of the visual experience of wind energy; solar collectors/reflectors may change their orientation and their reflective characteristics substantially in just a few hours or even minutes; and vapor plumes from cooling towers and boilers are in constant motion. Movement of objects in the landscape usually increases their visibility and may increase the visual contrast that is perceived by viewers (Benson 2005; Bishop 2002; Sullivan et al. 2012a; Sullivan et al. 2013a), so it is possible that failure to depict movement through the use of animation in simulations may result in lowered perceptions of visual contrasts associated with a project. Animations can depict viewer and object motion as well as change over time, but what is actually seen in the animation is still controlled entirely by the simulation creator, not the viewer, and animations are subject to output quality limitations as noted above.

5.5.2 Limitations to Contrast Range

Because photomontages are based on photographs, they are subject to the limitations of photography. A camera cannot capture the same range of visual contrast as the human eye (Scottish Natural Heritage 2006), and although the images can be manipulated to enhance color saturation and contrast slightly, simulations typically appear to be somewhat more flat and dull than real-life views of the landscape. The lower contrast shown in simulations than in the field may contribute to a lower perception of visual impacts than actually is observed when projects are built (Benson 2005). While this limitation affects all simulations based on photography, it is an especially important limitation for simulations depicting glare, such as the reflections from solar collector arrays and other facility components. Because of the extreme variation of brightness between glare and the surrounding landscape and the relatively limited dynamic range of contrast of the various output media, such as prints and computer screens, the glare is typically depicted as being less bright than actually observed in the field.

5.5.3 Limits to Field of View

Photographs also have a limited and predetermined field of view. They only show what is shown "within the frame," and the visual context provided by that part of the landscape that would be visible in real life but is outside of the field of view of the photograph is lost (Sheppard 1989, 2005). The visual context may in some cases be very important to determining the full effect that the addition of the project to the visible landscape would have. Panoramic simulations are often used to expand the field of view of simulations in order to show more of the surrounding landscape;

however, unless the image size at which the simulation is displayed is dramatically increased, the use of panoramic images may result in a loss of detail in the image. Furthermore, correct viewing of panoramic images is more complicated than for "normal" views, in part, because of apparent distortions that are observed when a panoramic image is projected onto a flat surface such as a screen or a printed page.

5.5.4 Limited Viewpoints

Simulations developed for views from KOPs can only depict the views from the specified KOPs and omit potential views of the project from many locations within the viewshed that are not KOPs or close to KOPs (Scottish Natural Heritage 2006). A typical EIS for a utility-scale renewable energy project will include simulations representing views of the project from a relatively small part of the total area from which the project would be visible. While well-selected KOPs may cover all viewpoints of major concern to stakeholders, it is important to remember that the project will be visible from many locations not represented by KOPs, and that a substantial portion of the total visual impact of the project may be experienced from these locations.

> **TIP**
>
> *Because of the limitations of simulations, NPS staff are strongly advised to bring simulations into the field and view them from the KOPs at the correct viewing distance, for direct comparison of the simulation with the existing landscape view. This will assist the reviewer in determining whether the simulation is accurate and realistic and will also facilitate better understanding of the potential visual contrasts from the proposed project.*

5.5.5 Viewing Distance Requirements

Finally, in order to see the project components in a simulation at the same size as they would be seen from the camera viewpoint in a real view of the landscape, the simulation must be viewed at a specific viewing distance (NZILA Education Foundation 2010; Scottish Natural Heritage 2006). The correct viewing distance for a photograph (or a simulation based on a photograph) is a function of the camera photographic sensor width, the focal length of the lens used to take the photograph, and the size at which the photograph is reproduced, for example, an 8½- × 11-in. page. The formula for determining the correct size of the image in relation to the distance viewed is as follows (National Academy of Sciences 2007):

$$\text{Distance from viewer} = \text{Width of image} /(2 \cdot \tan (\text{HFOV1} / 2)$$

Viewing the photograph at an incorrect viewing distance will result in objects within the photograph appearing larger or smaller than they would actually be seen in the real landscape. For visual simulations based on photographs, viewing the simulation from the incorrect viewing distance may result in the project appearing to be larger or smaller than would be observed in the field, which could result in an over- or under-estimation of the project's visual contrast (Sheppard 1989).

5.6 Sources of Error and Inaccuracy in Simulations

As noted, the development of spatially accurate and realistic simulations to support a VIA is a complex technical process that requires a high degree of skill, appropriate technology, accurate data, and rigorous methods. If improperly selected or prepared, simulations may be misleading, and the errors may not be apparent to casual observers. The following discussion examines major sources of errors and inaccuracy in simulations.

5.6.1 Improper Selection of KOPs and Simulation Parameters

Improper selection of KOPs may limit viewers' knowledge of the full range of visual impacts from a project, or worse still, may bias the impact assessment by not showing or fully disclosing important impacts. Sources of error include:

- Not selecting enough KOPs for simulations;
- Not selecting KOPs that represent the "worst-case scenario;"
- Selecting so many KOPs for simulations that viewers are bored or confused by viewing large numbers of simulations without significant differences;
- Omitting KOPs for simulation that are important to stakeholders; and
- Selecting KOPs for simulations that as a group over- or under-represent expected impacts.

Similarly, systematic selection of lighting conditions (as determined by date, time of day, weather, and atmospheric conditions) and other simulation parameters that over- or under-represent expected impacts may result in bias in the impact assessment. A common example is the exclusion of night-sky impact simulations for solar and wind facilities, which are known to have potentially substantial night-sky impacts.

> **TIP**
>
> *NPS staff should identify KOPs as early as possible and provide thoughtful input about particular simulations that are important to NPS's understanding of impacts. Simulations should be limited to those truly necessary to gain an understanding of the potential impacts of the proposed project.*

NPS staff should identify important KOPs as early as possible and provide thoughtful input about particular simulations that are important to NPS's understanding of impacts, for example, night-sky impact simulations, specific lighting or seasonal conditions, or the use of animations. If possible, NPS staff should accompany the visual impact analyst for field photography for NPS KOPs. Requested KOPs and simulations should be limited to those truly necessary to gain an understanding of the potential impacts of the proposed project.

5.6.2 Spatial Inaccuracy in Simulations

Spatial inaccuracy in simulations results from omitting elements that would be visible in the real landscape; showing elements that would not be visible; and showing objects in the wrong locations, at the wrong sizes, or in the wrong visual perspective. There are many potential sources of spatial inaccuracy in simulations. Some may introduce potentially large errors in contrast assessment; others typically result in minor errors in the assessment.

Inaccuracies potentially resulting in significant over- or under-estimation of visual contrast include:

- Changes to the project design after the simulations are prepared.
- Incorrect locations for the KOP or project elements, resulting in potentially significant location errors; however, large errors would likely be corrected prior to simulation development.

- Incorrect setup of viewing parameters in the visualization software, such as incorrect focal length specification.
- Errors in elevation data used to develop the simulation that occur near the KOP, potentially resulting in large-scale incorrect concealment or exposure of landforms and project elements.
- Failure to account for screening elements, such as vegetation and structures, that would be present or would be removed if the project were built.
- Use of incorrect or incomplete models of facility components.
- Project element models not oriented properly with respect to the viewer.

Inaccuracies typically resulting in minor over- or under-estimation of visual contrast include:

- Errors in elevation data used to develop the simulations that occur near the project location, potentially resulting in small-scale incorrect concealment or exposure of landforms and project elements.
- Failure to incorporate earth curvature and atmospheric refraction in simulation development, resulting in incorrect concealment or exposure of landforms and project elements. The effect of earth curvature is continuously variable, but at 10 mi, the elevation difference is approximately 55 ft; that is, at 10 mi, about 1/8 the height of a moderately sized wind turbine (measured to blade tip) would be hidden by earth curvature. At 5 mi, about 14 ft of the turbine would be hidden from view.
- Minor distortions inherent in the base photograph which will not be reflected in the 3D terrain model.
- Improper registration of terrain and project models with the base photograph.

> **TIP**
>
> *When evaluating simulations, be sure they reflect the current project design and request updated simulations where significant design changes have occurred.*

When evaluating simulations, be sure they reflect the current project design, as project designs may change frequently and substantially over the course of project development. Request updated simulations where significant changes to the design have occurred.

> **TIP**
>
> *Google Earth or Sketch-up, or similar free software, can be used to preview a project. The simulations may be primitive and lack realism but can be useful for getting a general overview of a project.*

NPS staff can use Google Earth and SketchUp, or similar free or inexpensive terrain and model visualization software, to preview project element location and orientation. The developer or visualization contractor should be able to provide facility models, or simple models can be easily constructed based on available project data. Models for wind turbines and transmission towers are frequently available at no cost through the Internet. Visualizations produced using Google Earth, SketchUp, and primitive models of facility elements will lack precision and realism. They also will not account for screening by vegetation or structures, but they may be useful for getting a general idea of the size and aspect of a project before accurate simulations are provided.

5.6.3 Lack of Realism in Simulations

A simulation may be spatially accurate but not realistic; that is, the project elements do not look the way they would in a real view of the project. For example, the project elements may be the wrong color, look cartoonish, have overly sharp visual edges, or not blend seamlessly with the background. Incorrect depiction of atmospheric haze effects can result in misperception of the distance from the viewer to the project. Errors in realism may be very subtle and difficult to detect but can change the perceived contrast of project elements, causing bias in impact assessment. Potential sources of a lack of realism in simulations include:

- Insufficient contrast, as discussed in Section 5.5.2. This is particularly important for depictions of glare from solar facilities and for lighting at all types of facilities.
- Over- or under-incorporation of distance and atmospheric effects, manifested as the project elements appearing too dull or hazy, or too clear and bright to match the surroundings.
- Improper coloring and shading of project elements, resulting in incorrect colors for project elements, a flat appearance, or an overemphasis on three-dimensionality.
- Improper blending of model edges with the background photograph, resulting in overly sharp or sawtooth edges on objects, or "mushy" blurred edges that are inconsistent with the edges of other objects in the base photograph.
- Incorrect lighting and shadow casting, often resulting from incorrect time specification for sun positioning that causes illumination and shadowing of the project elements that do not match the lighting and shadows in the base photograph.

> **TIP**
>
> *Detecting subtle problems with realism in simulations can be aided by having a photograph of a similar facility in a similar setting available for simultaneous viewing. Also, free or inexpensive mobile phone applications and Web sites provide easy-to-use tools to calculate sun positions, lighting directions, and shadow directions and length for any location at any time of year.*

5.6.4 Improper Display of Simulations

Simulations must be displayed properly in order for accurate impact assessments to be made, and also for stakeholder information purposes. Potential problems with simulation display include:

- Improper viewing distance, as discussed in Section 5.5.5. It is common for simulations to be reproduced at a size small enough that they cannot be comfortably viewed from the required viewing distance. In this situation, viewers will usually view the simulation from a comfortable distance that is farther than the required distance, resulting in the project appearing smaller than it would in reality.
- Lack of necessary detail in the displayed simulation. If simulations are presented at a small size, there may be insufficient detail to see project elements that may be important to accurate assessment of impacts. Detail may also be lost if low-quality reproductions are made, for

example, if a printed image is photocopied or a digital image is down-sampled to reduce file size for e-mail transmittal.

- Improper lighting. If lighting is overly bright and improperly positioned, there may be glare on printed simulations that makes details difficult to see. Insufficient lighting may also make details difficult to see, especially in darker images; however, as noted above, night-sky simulations should be viewed in dark conditions or else the lights depicted in the simulations will not be as bright as they would be seen in a real landscape.
- Lack of supplementary information. A variety of information (listed in Section 5.2.8) is needed to fully understand what is being shown and to understand important limitations and other important information about the simulation; however, this information is sometimes lacking.

TIP

The simulations included in typical paper copies of EISs downloaded from Web sites and printed on standard office printers are generally of insufficient quality for accurate impact assessment. They will usually be much duller in overall appearance relative to the real landscape view, often have incorrect colors, and usually lack details apparent in the original simulation. NPS staff should request that simulations be provided on photo-quality paper or (better yet) plotted on a high-resolution color plotter. The minimum size of the image should be 11 in. × 17 in.

5.6.5 Improper Documentation of Simulations and Methodology

Sound methodology and supporting documentation are required for producing defensible simulations in VIAs. However, adequate documentation of the methodology used and of the simulation production process may not be provided in VIAs and may otherwise be unobtainable.

5.7 Other Types of Simulations

While still-image and animated photomontages are the primary type of visual impact simulation used in EISs, several other types of simulations may be used for various purposes in the course of project development and may be encountered as part of stakeholder involvement activities. These are discussed below.

5.7.1 Wireframes

Wireframes are computer-generated line drawings of the landscape terrain and the project elements without realistic rendering and shading of the ground surface, vegetation, and project components. In essence, wire frames are “schematic” drawings of the project and the surrounding landscape. They can be developed and manipulated rapidly and are used extensively in the project siting and design process to show project elements in the proper location and at the correct size and aspect as they would be seen from a selected viewpoint. They can be useful in stakeholder involvement activities to explore alternative project designs and to develop basic visualizations of the project from different viewpoints. Wireframe images are also useful to check the spatial accuracy of simulations; that is, to determine that objects in the simulation are shown in the right location, at the right size, and in the proper visual perspective. However, the lack of surface rendering and shading results in visualizations that lack realism; the project and surrounding landscape do not look like they would in a real view of the landscape. Another limitation of wireframes is that for more complex landscapes and projects, the large number of lines involved can make the images very difficult to "read" and understand, especially for persons not familiar with this visualization method.

Because of these limitations, wireframe simulations are not suitable as finished simulations of projects and are often omitted from EISs, even though they are used extensively in the course of project development and in the preparation of the photomontages typically used to simulate views of the project. Wireframe simulations may sometimes be included in EISs to supplement other types of simulations.

Wireframes can also be superimposed onto photographs; typically this involves superimposition of the wireframe project elements onto a photograph of the existing landscape. If carefully done, so that the project elements are shown in the right location and correct visual perspective, this approach can combine the realism of the photograph with the spatial accuracy of the wireframe image to create an image that may be easier to understand than a regular wireframe image without the necessity for the complex surface rendering and shading needed to create a high-quality photomontage. While useful, the inclusion of the wireframe project elements still results in a lack of realism in the final simulation that makes these wireframe/photo hybrids inferior to well-executed photomontages for use in EISs.

5.7.2 Synthetic Landscape Renderings

Synthetic landscape renderings are computer-generated drawings of the landscape terrain and the project elements with realistic rendering and shading of the ground surface, vegetation, and project components. Unlike photomontages, synthetic landscape renderings are not modified photographs; the computer generates the entire viewed scene and thus can depict the landscape and project from any location. Sophisticated high-performance software, and often hardware, is typically used to develop synthetic landscape renderings and is capable of depicting surface textures, lighting, shadows, and atmospheric effects on visibility with a high degree of realism. High-quality synthetic landscape renderings may be nearly indistinguishable from photographs of the real landscape, at least in some settings. Multiple synthetic landscape rendering images can also be combined to create animated sequences.

The visualization of the millions of fine details and complex surfaces found within a real landscape setting is computationally complex and enormously demanding on computing resources. The development of synthetic landscape renderings requires advanced computing capabilities and skilled operators. The use of synthetic landscape renderings has historically been limited in EISs, in part because of the lack of suitable software/hardware to achieve high levels of realism in the simulations in a reasonable amount of time, and a lack of well-trained users of the software within the visual impact simulation profession. Even modern visualization systems may have difficulty rendering highly realistic complex foreground elements, especially vegetation, to the extent that the images fail to meet the "photorealistic quality threshold." This has resulted in limited use of synthetic landscape renderings for VIAs, though they are sometimes used to supplement photomontages. As computing systems advance, barriers to the use of synthetic landscape renderings will be reduced, and, eventually, they may replace photomontages in some applications.

5.7.3 Hand-Drawn Sketches, "Cut and Paste" Images, and Generic Facility Photographs

Hand-drawn sketches are rarely used in VIAs. While they may be useful for presenting conceptual information, they lack both the accuracy and realism necessary for judging visual impacts. Similarly, "cut and paste" images where a photograph, model, or sketch of the facility is overlaid onto a background photograph of the existing project setting without accurate registration and realistic rendering are unsuitable for use as simulations.

Generic photographs of existing facilities that are similar to the proposed project may be valuable for readers to understand the general appearance of the proposed facility. However, they are not a substitute for preparing spatially accurate and realistic simulations of the proposed project as it would be seen from KOPs, which are necessary for gaining a more realistic idea of the project's likely visual impacts.

Figure 5.3-1. A Photograph Of The Project Area For An Offshore Wind Facility Used As The Base Photograph For A Photomontage (Credit: BOEM)

Figure 5.3-2. Photomontage Production: 3D Wireframe Models of Wind Turbines Overlaid Onto a Base Photograph (Credit: BOEM)

Figure 5.3-3. A Spatially Accurate and Realistic Simulation of an Offshore Wind Facility (Note: the original simulation was shown at a larger size, at a much higher resolution, and with better color reproduction. Credit: BOEM)

6. Afterword

The Renewable Energy Age is upon us and is fundamentally changing the methods by which we use natural resources to provide the energy that is the foundation of our modern way of life. NPS welcomes this era and wants to ensure that it indeed is “smart from the start”; that is, proceeds in a way that also safeguards our nation’s natural and cultural heritage. Large-scale wind and solar facilities are being built across the country and soon will be built off our shores. They have the potential to fundamentally and permanently transform the scenic, historic, and cultural landscapes that Americans enjoy and value and that form part of our national identity. Indeed, that transformation is already taking place.

The National Park Service is charged by law with preserving the scenic values of NPS lands for the enjoyment of future generations. Views of the lands and waters outside NPS-administered areas form an integral part of visitors’ scenic experiences. These lands and waters form the backdrop for both iconic and everyday views of important scenic, historic, and cultural landscapes, and, of course, they are seamlessly integrated into the view. There are no visible boundary lines in the landscape, and visitors see and appreciate all parts of the visible landscape equally.

Large-scale wind and solar facilities, and the associated transmission projects built on lands outside NPS-administered areas, are currently affecting scenic views from some NPS-administered areas. As new facilities are inevitably built, the scenic impacts on NPS units are certain to increase. NPS staff are increasingly required to understand the scenic impacts of these projects and to participate in the planning and siting activities in order to minimize the scenic impacts on NPS resources.

This Guide is an important tool for NPS staff to learn about the scenic impacts of renewable energy facilities and electric transmission, to understand how scenic impacts are assessed, how to judge the accuracy and completeness of a scenic impact assessment, and most importantly, how to become an effective participant in the VIA and project planning and siting process. Active and early participation in these activities by NPS staff is essential to protecting park scenic values.

Although the Guide is intended to be a comprehensive resource, it is not meant to make NPS staff scenic resource experts. Help is available, and NPS staff are encouraged to contact the Visual Resource Specialist in the Air Resources Division of the Natural Resource Stewardship and Science Directorate to request assistance with issues relating to renewable energy impacts on park scenic resources.

Lastly, the Guide is intended to assist NPS staff in working collaboratively with others to protect scenic resources outside NPS units that are important to park scenic experiences. Ultimately, it is only through cooperative effort that our nation’s treasured landscapes can be preserved for future generations.

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8. Glossary

Access road
Gravel or dirt road (rarely paved) that provides overland access to transmission line and pipeline rights-of-way (ROWs) and facilities for inspection, maintenance, and decommissioning.

Air quality
Measure of the health-related and visual characteristics of the air to which the general public and the environment are exposed.

Ancillary structure/facility
Built feature (e.g., a substation) associated with a project that is not directly involved in power generation.

Animation
A sequence of still images combined to create the appearance of movement. When used for visual simulations, movement depicted in an animation may be of either the project components or the viewer location and shows change in the appearance of the project and the surrounding scene over time.

Area of analysis
The geographic area or areas to be included in a visual impact analysis.

Array
The positioning and spatial arrangement of energy collection devices (wind turbines or solar energy collectors [mirrors, heliostats, or panels]) of an energy facility, or the energy collection devices themselves, referred to collectively.

Aspect
The positioning of a building or thing in a specified direction; the direction that something (such as a building) faces or points toward. The aspect combined with the bearing determines which side of a facility is in view from a particular viewpoint, as well as the angle of the object's vertical surfaces with respect to the viewer.

Atmospheric refraction
The deviation of light from a straight line as it passes through the atmosphere due to the variation in air density as a function of altitude.

Audio Visual Warning System (AVWS)
A navigation hazard warning system that activates obstruction lighting and audio signals to alert aircraft pilots of potential collisions with tall obstacles, typically wind turbines or communications towers.

Aviation obstruction lighting
Lighting devices attached to tall structures as an aircraft collision avoidance measure.

Azimuth
The horizontal angular distance from a reference direction, usually the northern point of the horizon to the point where a vertical circle through a celestial body (e.g., the sun) intersects the horizon, usually measured clockwise.

Backdrop
The landscape, seascape, or sky visible directly behind the visible elements of a facility, as seen from a particular viewpoint.

Backlit
A lighting condition in which the side of an object facing the viewer is shaded because a light source beyond the object is illuminating it from behind.

Bearing
The compass direction from an observer to a viewed object.

Best management practice (BMP)
A practice or combination of practices that are determined to provide the most effective, environmentally sound, and economically feasible means of managing an activity and mitigating its impacts.

Blade
The aerodynamic structure on a wind turbine that catches the wind. Most utility-scale wind turbines have three blades.

Blade glint
A brief bright and sometimes repetitious reflection of sunlight from the surface of rotating wind turbine blades. *See* Glint; Glare.

Clutter
See Visual clutter.

Color
The property of reflecting light of a particular intensity and wavelength (or mixture of wavelengths) to which the eye is sensitive. Color is the major visual property of surfaces.

Concentrating PV
A solar energy system that uses mirrors or lenses to concentrate sunlight onto a collector.

Conductor
A substance or body that allows an electrical current to pass continuously along it. Electrical equipment receives power through electrical conductors. In electric transmission facilities, the cables (often called *lines*) that transmit electricity.

Construction and Operation Plan (COP)
A project planning document that for offshore wind facilities that includes design, fabrication, installation, and operations concepts as well as results of site surveys, offshore and onshore support, decommissioning plans, and a Navigational Risk Assessment.

Contrast
Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Cooling tower
A structure in which heat used in electricity generation in thermal power plants (including certain types of solar and geothermal power plants) is removed from hot condensate.

Cooperating agency
Any federal agency, other than a lead agency, that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposed project or project alternative.

Cultural resources
Archaeological sites, structures, or features; traditional use areas; and Native American sacred sites or special use areas that provide evidence of the prehistory and history of a community.

Cumulative impacts
The impacts assessed in an environmental impact statement that could potentially result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal), private industry, or individual undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Decommissioning
All activities necessary to take a facility out of service and dispose of its components after its useful life.

Developer
A person or company that builds or sells buildings or facilities on a piece of land. In the context of visual impact assessments, *developer* usually refers to the project proponent.

Digital elevation model (DEM)
A 3D representation of the surface terrain of an area. A DEM does not take into account trees, buildings, or other screening structures.

Direct impacts
Impacts occurring at or near the place of origin and at the time of a proposed activity, and occurring as a direct result of the activity. An effect that results solely from the siting, construction, operation, or decommissioning of a proposed action without intermediate steps or processes.

Distance zones
A set of pre-determined distances from a viewpoint. Typically, distance zones include a foreground, middle ground, and background zone that define visible portions of the landscape relative to the location of the observer

Dry-cooling system
Also known as dry closed-loop cooling; a technology for removing heat from the steam condensate of a thermoelectric plant. Cooling water circulates in a closed loop between a steam condenser, where it accepts heat from steam condensate and a dry condenser located outdoors. Fans are used to establish a flow of ambient air across the surface of the dry condenser, allowing the heated cooling water inside the dry condenser to transfer heat to the ambient air before cycling back to the steam condenser.

Ecoregion
A large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions.

Effects
Environmental consequences that occur as a result of a proposed action. Effects may be direct (caused by the action and occurring at the same time and place), indirect (caused by the action but occurring later in time or farther removed in distance but still reasonably foreseeable), or cumulative (incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions). In National Environmental Policy Act of 1969 (NEPA) documents, *effect* is synonymous with *impact*.

Environmental Assessment (EA)
A concise public document that a federal agency prepares under NEPA to provide sufficient evidence and analysis to determine whether a proposed action requires preparation of an Environmental Impact Statement (EIS), or whether a Finding of No Significant Impact (FONSI) can be issued. An EA must include brief discussions on the need for the proposal, the alternatives, the environmental impacts of the proposed action and alternatives, and a list of agencies and persons consulted.

Environmental Impact Statement (EIS)
An environmental impact assessment document required of federal agencies by NEPA for major proposals or legislation that will or could significantly affect the environment. An EIS must include a description of the proposed action, the environmental setting, and potentially affected areas. It must also include an analysis of reasonable alternatives to the proposed action, all environmental impacts related to the proposed action and its alternatives, and ways to identify, reduce, or avoid adverse impacts.

Facility
An existing or planned location or site at which equipment for converting mechanical, chemical, solar, thermal, and/or nuclear energy into electric energy is situated, or will be situated, and the equipment itself. A facility may contain more than one generator of either the same or different type.

Final Sale Notice (FSN)
The Final Sale Notice provides the final terms and conditions for a lease sale, including the date, time, and location for the sale itself as well as a list of companies that are legally, technically, and financially qualified to participate in the lease sale.

Footprint
The land or water area covered by a project. This includes direct physical coverage (i.e., the area on which the project physically stands) and the area of direct effects (i.e., the disturbances that may directly emanate from the project, such as noise).

Form
The mass or shape of an object or objects that appears unified, such as a vegetative opening in a forest, a cliff formation, or a water tank.

Fresnel lens
A thin optical lens consisting of concentric rings of segmental lenses and having a short focal length. As used in a concentrating photovoltaic solar facility, an optical focusing device that is placed in front of photovoltaic cells that concentrates the sunlight falling on the cells, thereby increasing power output.

Frontlit
A lighting condition in which the side of an object facing the viewer is fully illuminated by light coming from behind the viewer.

Galvanized (metallic surface)
A metal surface (particularly iron or steel) coated with zinc.

Generation (electricity)
The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, typically expressed in megawatt-hours (MWh).

Generation tie line (Gen-tie line)
An electric transmission facility constructed to interconnect and transmit electricity from a power generation facility to the electric grid.

Glare
The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility. *See also* Glint.

Glint
A momentary flash of light resulting from a spatially localized reflection of sunlight. *See also* Glare.

Grading
Mechanical process of moving earth to change the degree of rise or descent (slope) of the land in order to establish good drainage, and to otherwise suit the intent of a landscape or engineering site design.

Hazard navigation lighting
The illumination of an object for increased conspicuity to ensure the safety of air or water navigation, or the lighting equipment used to achieve this purpose.

Heat transfer fluid (HTF)
Fluid that transfers heat generated at the solar collectors or in geothermal systems to a heat exchanger where steam is produced to run a steam generator.

Heliostat
A solar power tower facility component consisting of a large, nearly flat mirror, usually on a tracker, pedestal, or other support structure, that allows it to continuously reflect the sun's rays over the course of the day onto a central receiver at the top of a centrally positioned tower.

Horizon line
The apparent line in the landscape formed by the meeting of the visible land surface and the sky, or any line of a structure or landform feature that is parallel to that line.

Horizontal field of view
The horizontal extent of the observable landscape that is seen at any given moment, usually measured in degrees.

Hybrid (wet-dry cooling) system
A variation on a power generation facility dry-cooling system. In a hybrid system, small amounts of water are sprayed as a fine mist into the flow of ambient air being directed over the surface of a dry condenser. The water evaporates, cooling the air as it does so. Alternatively, water is deluged over the surface of the dry condenser where it evaporates after interacting with the overflowing ambient air stream, cooling that air. Wet/dry hybrid systems consume only minor amounts of water (compared with wet closed-loop cooling) but offer significantly better performance than dry-cooling systems, especially in hot climates with low relative humidity.

Impact
The effect, influence, alteration, or imprint caused by an action. *See* Effects.

Indirect impacts
Impacts that occur away from the place of origin, either in space and/or in time. An effect that is related to, but removed from, a proposed action by an intermediate step or process.

Irreversible/irretrievable commitments of resources
Impacts on or permanent losses to resources that cannot be recovered or reversed. Irreversible describes the loss of future options and applies primarily to nonrenewable resources. Irretrievable applies to the loss of production, harvest, or use of natural resources.

Key observation point (KOP)
A point at a use area or a potential use area, or a series of points or a segment on a travel route, where there may be views of a management activity. KOPs are typically used as viewpoints for assessing potential visual impacts resulting from a proposed activity, such as the construction and operation of a power generation facility.

Landform
Any recognizable physical form of the earth's surface having a characteristic shape. Landforms include major forms such as plains, plateaus, and mountains, and minor forms such as hills, valleys, slopes, and moraines. Taken together, the landforms make up the surface configuration of the earth.

Landscape
The expanse of visible scenery, including landforms, waterforms, vegetation, and man-made elements such as roads and structures. Also the traits, patterns, and structure of a specific geographic area, including its physical environment, its biological composition, and its anthropogenic or social patterns.

Land use
A characterization of land in terms of its potential utility for various activities, or the activities carried out on a given piece of land.

Laydown area
An area that has been cleared for the temporary storage of equipment and supplies for a construction activity; a location where individual components for use in construction are initially offloaded from their transport vehicle. To ensure accessibility and safe maneuverability for transport and offloading of vehicles, laydown areas are usually covered with rock and/or gravel.

Lease area
A specific area leased for a specific period of time under certain agreed-upon terms and conditions.

Line
The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as ridges, skylines, the edges of structures, the edges of water bodies, changes in vegetative types, or individual trees and branches.

Luminosity
The brightness of a light source of a certain wavelength as it appears to the eye.

Mirror
A reflecting surface of one of various physical shapes (parabolic, nearly flat, or flat) used to reflect and/or concentrate the sun's energy to specific locations within solar energy facilities.

Mitigation
A method or process by which impacts from actions can be made less injurious to the environment through appropriate protective measures.

Mitigation measures
Methods or actions that will reduce adverse impacts from facility development. Mitigation measures can include best management practices, stipulations in Bureau of Land Management (BLM) ROW agreements, siting criteria, and technology controls.

Monitoring
Observation of construction, operation, and decommissioning activities to ensure proper mitigation measures or other resource protection protocols are being followed. Long-term monitoring observes the progress or quality of mitigation measures over a period of time.

Nacelle
The housing that contains and protects the major components (e.g., generator and gear box) of a wind turbine.

National Historic Preservation Act (NHPA)
A federal law providing that property resources with significant national historic value be placed on the *National Register of Historic Places*. It does not require permits; rather, it mandates consultation with the proper agencies whenever it is determined that a proposed action might impact a historic property.

National Elevation Dataset (NED)
A seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands. The NED serves as the elevation layer of The National Map, and provides basic elevation information for earth science studies and mapping applications in the United States.

National Register of Historic Places (NRHP)
A comprehensive list of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The NRHP is administered by the National Park Service, which is part of the U.S. Department of the Interior.

Night-sky impact
An interference with enjoyment of dark night skies, or an effect on nocturnal wildlife resulting from artificial light pollution, such as may be caused by facility or other lighting.

Observer position
The viewer’s elevation with respect to a viewed object. Possible values include *superior* (the observer is elevated with respect to the object and is looking down at it), *normal* (the observer is at the same approximate elevation with respect to the object and is looking across the landscape at it), and *inferior* (the observer is at a lower elevation than the object and is looking up at it).

Operator
A person driving or controlling a piece of construction equipment.

Outer Continental Shelf (OCS)
Al submerged lands, subsoil, and seabed that belong to the United States and are lying seaward and outside of the coastal states' jurisdiction.

Parabolic trough
A type of concentrating solar power (CSP) solar energy technology that uses parabola-shaped mirrors to concentrate sunlight on a receiver tube filled with flowing heat transfer fluid. The flowing heat transfer fluid subsequently transfers the heat it absorbs to water to produce steam to drive a steam turbine generator (STG) that generates electricity. Parabolic trough systems typically mount the mirrors on a support that can track the sun’s apparent east-to-west movement across the sky over the course of the day to increase solar energy capture.

Penalty clause
A statement in a contract that allows one party to charge extra money if the other party fails to follow the terms of the contract.

Photomontage
A still image of a highly realistic 3D model of a proposed facility superimposed onto a photograph of the existing landscape.

Photovoltaic (PV)
Technology that utilizes semiconducting materials that convert the energy in sunlight directly into electricity.

Pipeline
A line of pipe with pumping machinery and apparatus for conveying liquids, gases, or finely divided solids between distant points.

Plan of Development (POD)
A document submitted to obtain authorization to use federal lands for construction, operation, and maintenance of a project. Includes engineering design information and mitigation measures.

Plant
A facility that is the location of equipment for converting mechanical, chemical, solar, thermal, and/or nuclear energy into electric energy.

Plume
A visible discharge of vapor and/or particulate matter from a given point of origin, for example, water vapor from a cooling tower at a power plant.

Power tower
A type of CSP technology composed of many large, sun-tracking mirrors (heliostats) that focus sunlight on a receiver at the top of a centrally located tower. The sunlight heats up a heat transfer fluid in the receiver, which then is used to generate steam (or directly heats water to produce steam) that powers an STG to produce electricity. Power tower systems can also be equipped with molten salt in which the heat generated at the receiver can be stored for delayed production of electricity.

Proposed Sale Notice
A notice published by the Bureau of Ocean and Energy Management (BOEM) in the *Federal Register* that describes the proposed areas to be offered for leasing and the proposed conditions of the lease sale.

Receiver
A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat.

Reclamation
The process of restoring the surface environment to acceptable pre-existing conditions.

Record of Decision (ROD)
A document separate from, but associated with an EIS that publicly and officially discloses the responsible agency's decision on the EIS alternative to be implemented.

Reflective
Capable of physically reflecting light or sound.

Reflectivity
The fraction of radiant energy that is reflected from a surface.

Renewable energy
Energy derived from resources that are regenerative or that cannot be depleted. Renewable energy resources include wind, solar, biomass, geothermal, and moving water.

Resource Management Plan
A written plan that addresses the existing resources of an area and provides future objectives, goals, and management direction.

Revegetation
The process of replanting on disturbed land. This may be a natural process produced by plant colonization and succession, or an artificial (man-made), accelerated process designed to replace vegetation that has been damaged, destroyed, or removed due to wildfire, mining, flood, development, or other causes.

Right-of-way (ROW)
Public land authorized to be used or occupied pursuant to a ROW grant. A ROW grant authorizes the use of a ROW over, upon, under, or through public lands for construction, operation, maintenance, and termination of a project.

Seascape
The expanse of visible ocean, sea, or lake scenery.

Scenery Management System (SMS)
The U.S. Department of Agriculture Forest Service system for managing scenery and determining the relative value and importance of scenery in a national forest.

Scenic integrity
The degree of "intactness" of a landscape which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances.

Scenic quality
A measure of the intrinsic beauty of landform, waterform, or vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Scenic quality rating
An assessment of scenic quality. For example, in the BLM's Visual Resource Inventory (VRI) process, public lands are given an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.

Scenic resource area
A physical area composed of land, water, biotic and/or cultural elements which have inherent scenic qualities and/or aesthetic value.

Scenic value
The importance of a landscape based on human perception of the intrinsic beauty of landform, waterform, and vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Screening
A visual barrier consisting of earth, vegetation, structures, or other materials intended to block a particular view, or the actual blocking of a view through the use of a visual barrier.

Sensitive viewpoint
A location that is valued or considered important because of the views of the landscape that it affords.

Shadow flicker
Refers to the flickering effect that occurs when a wind turbine casts shadows over structures and/or observers at times of day when the sun is directly behind the turbine rotor relative to the observer's position.

Sidelit
A lighting condition in which the side of an object facing the viewer is partly illuminated and partly shaded because sunlight is falling more or less perpendicular to the line of sight between the viewer and the object.

Site Assessment Plan (SAP)
A written document describing the project area, results of any pre-construction site investigations, and activities a developer plans to perform on the proposed project site.

Surface Elevation Model (SEM)
A 3D representation of the surface terrain of an area that takes into account trees, buildings, or other screening structures in determining elevation.

Skylining
Siting of a structure on or near a ridgeline so that it is silhouetted against the sky as seen from a specified viewpoint.

Solar altitude (Solar elevation)
The angular height of the sun above or below the horizon, usually measured in degrees. Above the horizon, solar altitude is positive, below the horizon, solar altitude is negative. Also referred to as "solar elevation."

Solar array
See Solar collector array.

Solar collector
A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat or electricity. Major components include panels (for PV facilities) and mirrors or reflectors (for CSP facilities), additional features designed to further concentrate the incident sunlight (in some facilities), and a receiver or tube containing a heat transfer fluid (for CSP facilities).

Solar collector array
That portion of the solar energy facility containing components that track and/or capture sunlight and convert it to other useful forms of energy, typically heat or electricity. Solar collector arrays are typically composed of panels (for PV facilities), parabolic mirrors or heliostats and receivers containing some form of heat transfer fluid (for CSP facilities), and support structures and controls that allow the panels or mirrors/heliostats to track the sun over the course of the day to maximize solar energy capture. Together, all components of the solar array make up what is known as the solar field of a solar energy facility.

Specular reflection
Also known as direct reflection, regular reflection, or mirror reflection. The reflection of electromagnetic rays without scattering or diffusion. In specular reflection, the angle at which the wave is incident on the reflecting surface is equal to the angle at which it is reflected from that surface. *See also* Glint; Glare.

Stakeholder
A person or group who has an interest or concern in the proposed project.

Substation
A facility containing equipment through which electricity is passed for transmission, transformation, distribution, or switching. Substations generally include switching, protection and control equipment, and transformers, but the equipment present and the size of the substation vary depending on the particular functions of the substation.

Sun angle
The angle of the sun (solar altitude) above the horizon of the earth and its bearing (solar azimuth).

Texture
The visual manifestations of light and shadow created by the variations in the surface of an object or landscape.

Texture contrasts
Visual contrasts between different objects or landscapes resulting from different visual manifestations of texture.

Topography
The shape of the earth's surface; the relative position and elevations of natural and man-made features of an area.

Tower
The base structure that supports and elevates a wind turbine rotor and nacelle. "Tower" may also refer to a transmission tower, or the central receiving tower of a power tower solar facility.

Transmission (electric)
The movement or transfer of electricity over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer. Also the interconnected group of lines and associated equipment that performs this transfer.

Transmission line
A set of electrical current conductors, insulators, supporting structures, and associated equipment used to move large quantities of power at high voltage, usually over long distances (e.g., between a power plant and the communities that it serves).

Transmission tower
A support structure for lines (conductors) that transmit high-voltage electricity.

Turbine
A machine for generating rotary mechanical power from the energy of a stream of fluid (such as wind, water, steam, or hot gas), in which a stream of fluid turns a bladed wheel, converting the kinetic energy of the fluid flow into mechanical energy available from the turbine shaft. Turbines are considered the most economical means of turning large electrical generators. *See* Wind turbine.

Turbine array
Any number of wind energy conversion devices that are connected together to provide electrical energy.

Utility (electric)
A company that engages in the generation, transmission, and/or distribution of electricity.

Utility-scale
Descriptive term for energy facilities that generate large amounts of electricity that is delivered to many users through transmission and distribution systems.

Vapor plume
Air, super-saturated with water vapor and often containing solid, liquid, or gaseous contaminants, that is vented from industrial processes and is visible because it contains water droplets.

Vegetation
Plant life or total plant cover in an area.

Viewed landscape
The geographic area that can be seen from a given viewpoint.

Viewer characteristics
Traits of the individual viewer, such as visual acuity, visual engagement, and experience, and viewer motion that affect the viewer's perception of contrast and the ability to discern objects in the landscape.

Viewer motion
Change in position of the viewer within the landscape. The visual experience changes as the viewer moves through the landscape.

Viewing geometry
The spatial relationship of viewer to the viewed object (e.g., a renewable energy facility), including the viewer position and aspect.

Viewpoint
A point from which a landscape is viewed. Also a point from which a landscape view is analyzed and/or evaluated.

Viewshed
The total landscape seen or potentially seen from a point, or from all or a logical part of a travel route, use area, or water body.

Viewshed analysis
A spatial analysis that uses elevation data such as a DEM or SEM to determine which parts of the surrounding landscape are likely to be visible from a designated point or points.

Viewshed limiting factors
Variables that determine the nature and size of the viewshed from a given viewpoint, within the maximum distance of analysis set by the user, so called because they define the spatial limits of the viewshed. Viewshed limiting factors include the following: topography, vegetation, structures, viewer height, target height, earth curvature, and atmospheric refraction.

Viewshed map
The outcome of a viewshed analysis that shows which areas of the surrounding landscape would theoretically be visible from the viewshed origin (the viewpoint).

Visibility
The ability to visually discern an object in the landscape; also, the distance an individual can see as determined by light and weather conditions.

Visibility factors
Variables that determine and affect the visibility and apparent visual characteristics of an object in a landscape setting. Visibility factors include viewshed-limiting factors that define the potentially visible area, viewer characteristics, distance, viewing geometry, background/backdrop, lighting, atmospheric conditions, and the object's visual characteristics.

Visual acuity
The acuteness or clarity of vision.

Visual attention
Noticing and focusing of vision on a particular object or landscape element.

Visual clutter
The complex visual interplay of numerous disharmonious landscape characteristics and features resulting in a displeasing view.

Visual contrast
Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Visual contrast rating
An assessment of the visual contrast between a project and the surrounding landscape. In the BLM's Visual Contrast Rating process, the contrast is measured by comparing the project features with the major features in the existing landscape. The basic design elements of form, line, color, and texture are used to make this comparison and to describe the visual contrast created by the project.

Visual engagement/experience
How closely the viewer looks at an object or objects in the landscape.

Visual experience
The degree of familiarity with the visual characteristics of a particular object in the landscape based on having seen it previously.

Visual impact
Any modification in landforms, water bodies, or vegetation, or any introduction of structures or other human-made visual elements, that negatively or positively affect the visual character or quality of a landscape and the visual experience of persons viewing the landscape through the introduction of visual contrasts in the basic elements of form, line, color, and texture.

Visual Impact Assessment (VIA)
Analysis of the visual impacts of a proposed project, usually presented as a stand-alone technical report or contained within an EIS.

Visualization
Development of pictorial representation (usually using computer hardware and software) of a proposed facility.

Visual mitigation
Actions taken to avoid, eliminate, or reduce potential adverse impacts on scenic resources.

Visual resource
Any objects (man-made and natural, moving and stationary) and features, such as landforms and water bodies, that are visible on a landscape.

Visual Resource Inventory (VRI)
Any systematic assessment of the visual resources present within a specified landscape, but also more specifically, a BLM process for inventorying scenic resources on BLM-administered lands that provides BLM managers with a means for determining relative visual values. A BLM VRI consists of a scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. Based on these three factors, BLM-administered lands are placed into one of four VRI classes.

Visual resource management (VRM)
The planning, design, and implementation of management objectives for maintaining scenic values and visual quality.

Visual Resource Management (VRM) Classes
Scenic resource management objectives assigned to BLM-administered lands in the Resource Management Plan process, which prescribe the amount of change allowed in the characteristic landscape. There are four VRM classes: I (most protected), II, III, and IV (Least protected).

Visual Resource Management (VRM) System
BLM's system for minimizing the visual impacts of surface-disturbing activities and maintaining scenic values for the future; specifically, the inventory and planning actions taken to identify visual values and to establish objectives for managing those values; also the management actions taken to achieve the visual management objectives.

Visual sensitivity
Public concern for the maintenance of scenic quality in a particular landscape setting.

Visual simulation
A pictorial representation of a proposed project in its landscape setting, as it would be seen from a specified viewpoint, and used to visualize the project before it is built, typically in order to determine its potential visual contrasts and associated visual impacts.

Visual value
See Scenic value.

Wild and Scenic River
A designation (under the Wild and Scenic Rivers Act of 1968) for certain rivers that are to be preserved for possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. A river or river section may be designated by Congress or the Secretary of the Interior. National Wild and Scenic rivers are managed by agencies of the federal or state governments.

Wind energy
The kinetic energy of wind converted into mechanical energy by wind turbines (i.e., blades rotating from a hub) that drive generators to produce electricity for distribution. *See* Wind power.

Wind farm
One or more wind turbines operating within a contiguous area for the purpose of generating electricity.

Wind power
Power generated using a wind turbine to convert the mechanical power of the wind into electrical power. *See* Wind energy.

Wind turbine
A term used for a device that converts wind energy into mechanical energy that is used to produce electricity.

Appendix A: Viewshed Analysis

A.1 Viewshed Analysis

Visual impact assessment (VIA) analysts use the term **viewshed** to describe areas visible from a given point or points, and determining the project's viewshed is a key step in VIA. Identifying the viewshed for the project and the associated activities is accomplished primarily through **viewshed analysis**, a spatial analysis that uses elevation data (and sometimes landcover data) to determine which parts of the surrounding landscape are theoretically visible from a designated point or points. Viewshed analysis for VIAs is routinely conducted using geographical information system (GIS) software.

A.2 Elevation Data

Viewshed analyses use elevation data to determine whether topography, and, in some cases, vegetation and structures, blocks views of the project from other locations in the area of the viewshed analysis. Viewshed analyses can be run from the project location to determine all areas from which the project is potentially visible, or they can be run from potential project observation points to determine whether and how much of the project and the surrounding lands are visible from that point. For a typical VIA, viewshed analyses are almost always run from the project location to determine areas from which the project may be visible; this information is then used to identify potential key observation points (KOPs) (see Section 1.5 of this Guide). Viewshed analyses from potential project observation points are less commonly run early in the analysis process; they may be useful, however, for projects that cover very large areas, such as wind energy facilities, to show how much of a project may be visible from a specific location.

Most commonly, the elevation data used in the viewshed analysis is in the form of a **Digital Elevation Model** (DEM) that includes only the land surface and does not include trees, buildings, or other structures that could screen views of the project; these screening elements and related properties are referred to as *viewshed limiting factors*, and are discussed in greater depth in Appendix B. More rarely, a **Surface Elevation Model** (SEM) is used; an SEM does account for tree height and other screening elements in determining elevation. Unless an SEM is used, or the viewshed height setting is adjusted to account for vegetation or other obstructions that might screen the project from view, the viewshed results will be less accurate and may seriously overestimate project visibility. In parts of the Southwest, there is so little tall vegetation and so few structures, that not accounting for screening has little effect on the results of the viewshed analysis; however, in many parts of the country, and especially in forested or urban landscapes, trees and buildings block significant portions of most views. Information about landcover that was gathered for the affected environment analysis can be used to help determine the nature and extent of potential screening, as can a site visit. In some cases, Light Detection And Ranging (LiDAR) data may be available that provides high-accuracy elevation data, and may be available as both a DEM and an SEM.

The National Elevation Dataset (NED) is a publicly available and free source of DEM elevation data for use in viewshed analyses. NED data are available in standard GIS-compatible format. Currently, NED data are available at 10-m resolution (i.e., 10-m grid cells) for all U.S. states except Alaska. As a general rule, NED or other 10-m data should be used for viewshed analyses if available; more coarse elevation data can result in relatively large errors in the viewshed analysis.

Both DEMs and SEMs are not perfectly accurate representations of elevation, and different GIS tools will calculate the viewshed slightly differently. Thus it is best to consider viewshed analyses as good approximations of visibility; to validate visibility for a particular location, fieldwork is necessary. Where screening is a significant factor (e.g., forested areas), field inspection will be critical, or the use of an SEM is advisable.

A.3 Viewshed Maps

The output of a viewshed analysis is a viewshed map that shows which areas surrounding the viewshed origin (in this case the project) are within the project viewshed, meaning observers at those points could potentially see at least some portion of the proposed project. Because some renewable energy project elements are very tall, such as wind turbines, solar power towers, and transmission towers, their height may extend their visibility considerably, and the viewshed analysis may be adjusted to account for the height of the project elements. If it does not, the viewshed results will be less accurate, as it may significantly underestimate project visibility.

A.4 Earth Curvature and Refraction

Two other factors that will affect viewshed results are **earth curvature** and **refraction**. At long distances, the curvature of the earth will begin to conceal objects at the horizon that would be visible in the absence of earth curvature. In addition, the atmospheric phenomenon of refraction will bend light and cause objects that would actually be below the horizon in the absence of refraction to appear above the horizon. The effect of earth curvature is much greater than that of refraction for a given distance. While these effects are minimal at short distances, at very long distances they can change visibility results noticeably. Because some renewable energy facilities are visible at distances exceeding 20 or even 30 mi, it is important to account for earth curvature, and, ideally, for refraction in calculating viewsheds. Some GIS software allows setting parameters to account for these effects in the viewshed calculation. The VIA should clearly identify whether curvature of the earth and refraction have been accounted for in the GIS analysis and state the rationale for why they are or are not included. Refraction is a variable phenomenon, and a “rule-of-thumb” value must generally be applied.

A.5 Radius of Analysis

The radius for the viewshed analysis (i.e., the area considered in the visibility analysis) is predetermined and generally coincides with the some determination of the area in which non-negligible impacts are expected. There is no widely accepted standard radius of analysis, and no “one size fits all” distance for either renewable energy facilities or transmission lines, and there are a number of factors to consider.

Wind turbines and some solar facilities are inherently more visible than many other industrial facilities because of structure height, visual mass, color and reflectivity, project size, and in the case of wind turbines, blade motion and aviation obstruction lighting at night. Wind facilities have been determined to be visible at distances exceeding 30 mi in both day and night viewing (Sullivan et al. 2012), and offshore wind turbines have been determined to be visible at distances exceeding 25 mi (Sullivan et al., 2013). The reflected light from solar power towers has been determined to be visible at distances exceeding 20 mi (Sullivan et al. 2014) and may be visible for much longer distances; however, additional research is needed to establish appropriate radii for impact analyses for utility-scale renewable energy projects.

Regional differences in visibility (primarily because of differences in levels of air pollution and humidity) suggest that the radius of analysis should vary by region. In general, recommendations for wind projects range from 25 to 30 mi in western landscapes, to as low as 8 mi in the Northeast (Clean Energy States Alliance 2011). Of course, the local topography may restrict visibility to shorter distances than these.

A.6 Specialized Viewshed Analyses

More specialized viewshed analyses are sometimes conducted for VIAs; these may include composite viewsheds that indicate visibility of areas from multiple KOPs, viewsheds that calculate the number of wind turbines in view from a KOP, and viewsheds that indicate the height of an object at a given location that could be concealed from view of a KOP. These types of specialized viewshed analyses are particularly valuable for linear KOPs, such as roads or trails, where a project may be viewed from multiple locations as part of a sequential visual experience. National Park Service (NPS) staff may wish to request that these types of specialized viewshed analyses be employed where applicable.

A.7 References

Clean Energy States Alliance. 2011. A Visual Impact Assessment Process for Wind Energy Projects. May.

Sullivan, R., et al. 2012. “Wind Turbine Visibility and Visual Impact Threshold Distances in Western Landscapes.” In Proceedings, National Association of Environmental Professionals, 37th Annual Conference, May 21–24, 2012, Portland, Ore.

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Sullivan, R., et al. 2014. “Utility-Scale Solar Energy Facility Visual Impact Characterization and Mitigation Project Final Report.” Argonne National Laboratory, Argonne, Ill.

Appendix B: Visibility Factors

B.1 Visibility Factors

Regardless of the simulation technology employed, the proper interpretation of simulations, and, more importantly, a good understanding of the real visual contrasts of a proposed facility, requires a basic understanding of the visual perception of objects in the landscape. In many landscapes, utility-scale wind, solar, and transmission facilities may create strong visual contrasts with scenic settings because these projects cover very large areas, and the structures involved can be very tall and/or highly reflective. All three technologies involve structures with distinctly man-made geometry that may contrast strongly with natural-appearing backgrounds when lighting conditions and viewing angles are suitable, and viewers are within a certain distance of the facility. However, at other times, even when viewed from the same location, the facilities may be invisible; they may be visible but hard to distinguish from the background; or they may be plainly visible but appear substantially different than they have appeared at other times. The visibility of an object in a landscape setting and its apparent visual characteristics for any given view, are the result of a complex interplay among the observer, the observed object, and various factors that affect visual perception, referred to as *visibility factors*. There are eight major types of visibility factors that affect perception of large objects in the landscape:

- Viewer characteristics;
- Viewshed limiting factors;
- Lighting factors;
- Atmospheric conditions;
- Distance;
- Viewing geometry;
- Backdrop; and
- Object visual characteristics.

All of the visibility factors and their spatial relationships in the landscape are depicted conceptually in Figure B-1.

B.2 Viewer Characteristics

Characteristics of the viewer affect the perception of contrast and the ability to discern objects in the landscape. *Visual acuity* is the acuteness or clarity of vision. *Visual engagement and experience* refer to how closely the viewer is looking at the landscape, whether he/she is looking for a particular object or type of object, and his/her familiarity with the type of object. *Viewer motion* may change the aspect of the viewed facility, but it can also limit the duration of views.

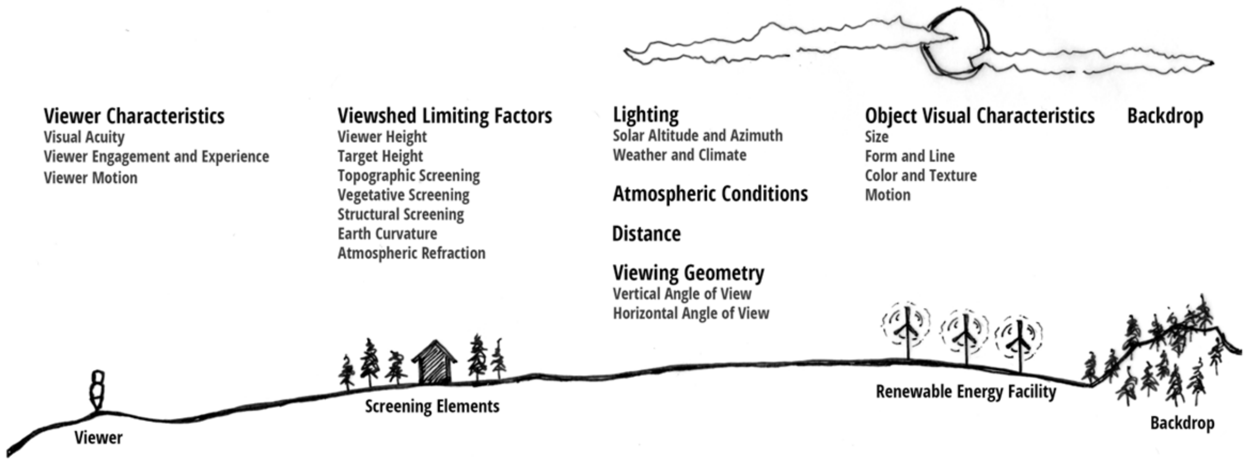


Figure B-1. Schematic Diagram of Visibility Factors in the Landscape (Credit: Argonne National Laboratory)

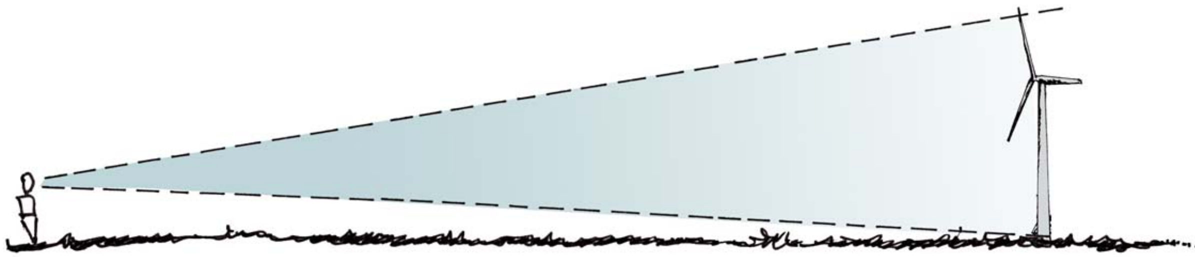
- **Visual acuity:** Visual acuity is the ability to discern visual details and is a physical limitation of the human vision system. It varies among individuals and decreases with age, but generally can be corrected with eyeglasses, contact lenses, surgery, etc.
- **Viewer engagement and experience:** Seeing is an active process that involves scanning the landscape to pick out recognizable objects from the background, to look for patterns, and in general, to organize and make sense of the jumble of forms, lines, colors, and textures presented to the eye. While much of this activity happens without conscious effort, viewers who are consciously and actively focusing on the landscape will normally be better able to discern particular objects, particularly if they know what they are looking for, and especially if they have previous visual experience with the object, such that they have a mental "template" to help them predict the forms, lines, colors, and textures they should be looking for as they scan the view.
- **Viewer motion:** If the viewer is moving through the landscape, the visual experience differs from that of a static viewer. If the viewer is moving directly toward or away from the facility, the general aspect of the facility will not change, but its apparent size will, and the level of contrast it creates will change similarly. If the viewer is moving perpendicular to the line of sight to the facility (i.e., the facility is moving across the field of view), the facility may seem to move across its visual backdrop. The contrast from the facility may change dynamically as the color and texture of the backdrop change. The portions of the facility in view may change as well. Viewer motion may also tend to decrease the duration of views of the facility.

B.3 Viewshed Limiting Factors

Several factors determine the spatial extent of the viewshed from a given viewpoint, within the maximum distance of analysis set by the user; these factors are here referred to as *viewshed limiting factors*, because they define the spatial limits of the viewshed. They include the following:

- **Topography:** Terrain such as a ridge or hill may block the view from a particular location; in hilly or mountainous areas, topography has a major effect on the shape and size of the viewshed. The elevation data used in the viewshed analysis provide information used in the analysis to determine topographic screening.
- **Vegetation:** Vegetation, typically trees, may screen views fully or partially, especially close to the viewpoint. In some landscapes, vegetation tall enough to screen views is sparse or absent; however, where it is present and of sufficient density to block views, it can affect the size and shape of the viewshed. Specialized elevation data may be required to account for vegetation height in a viewshed analysis, unless a standard vegetation height can be calculated and incorporated into the viewshed analysis. In areas with deciduous vegetation, seasonal leaf drop may affect the extent of screening. Views may be screened less effectively when leaves are shed.
- **Structures:** Man-made structures may also screen views fully or partially, especially if they are close to the viewpoint. Similarly to vegetation, specialized elevation data may be required to account for structure height in a viewshed analysis, unless the location and height of each structure can be incorporated into the viewshed analysis.
- **Viewer height:** The eyes of a standing adult are generally between 5 and 6 ft above the ground surface, so viewers see more than they would if their eyes were at ground level; this height must be added to the viewpoint elevation to obtain an accurate result from the viewshed analysis. If the viewpoint is further elevated (e.g., the viewpoint is at the top of a building), then the heights of both the viewer and the structure must both be accounted for in the viewshed analysis. Viewer height is a typical input setting for a viewshed analysis.
- **Target height:** Tall objects may project above topographic or other screening, and if a viewshed analysis is being run to determine visibility of a particular type of object (e.g., a wind turbine), the height of the object must be accounted for in the viewshed analysis. Target height is a typical input setting for a viewshed analysis. The components of the proposed energy facility should be considered when determining the target height to be used for viewshed analysis. Solar facility component height varies widely depending on the solar technology employed. Wind turbines also vary in height, and the viewshed analysis must account for the blade tip height in addition to the hub height.
- **Earth curvature:** The curvature of the earth’s surface will affect viewshed results at long distances; if earth curvature is not accounted for in the viewshed calculation, objects at longer distances will be indicated as visible, when, in fact, the curvature of the earth would have caused them to drop partially or completely below the horizon (see Figure B-2). Earth curvature incorporation is a typical setting for a viewshed analysis. For large structures, such as renewable energy facilities that may be visible for very long distances (25 mi or more for wind and solar

facilities), earth curvature can substantially reduce structure visibility, and it is important that it be accounted for in visibility analyses.



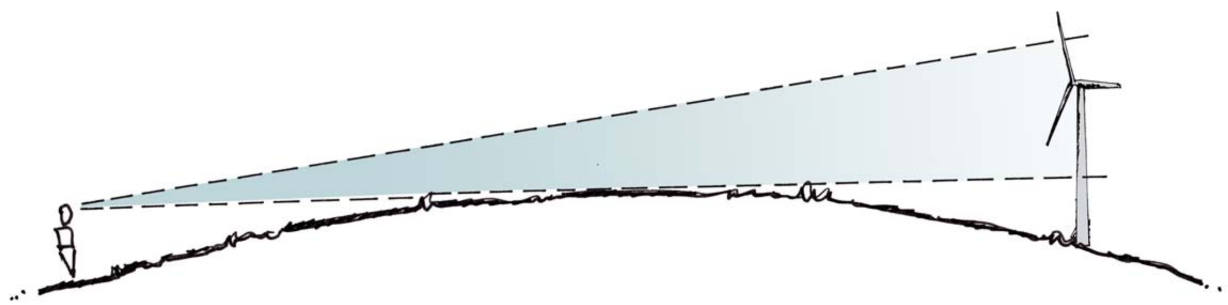


Figure B-2. Over A Sufficiently Long Distance, Curvature Of The Earth Will Partially Or Completely Screen Views Of Objects In The Landscape (Objects And Earth Curvature Are Not Drawn To Scale.) (Credit: Argonne National Laboratory)

- **Atmospheric refraction**: Atmospheric refraction is the deviation of light from a straight line as it passes through the atmosphere due to the variation in air density as a function of altitude. Atmospheric refraction will bend light and cause objects that would actually be below the horizon in the absence of refraction to appear above the horizon. Atmospheric refraction may slightly increase the visibility of distant objects; however, the effect is very small and variable. Because refraction is a variable phenomenon, a “rule-of-thumb” value must generally be applied.

B.4 Lighting

The intensity and distribution of lighting have a profound effect on the apparent color of objects and their backgrounds. The angle of sunlight falling on an object may result in shadows that greatly increase its apparent contrast with the background. Sunlight can cause glare from solar mirrors, transmission towers, and conductors, glinting from wind turbine blades, and can cause dramatic increases or decreases in facility visibility as it interacts with clouds. Lighting’s effects on visibility are complex and interact with other visibility factors, such as atmospheric conditions and the surface characteristics of structures. The sun angle is expressed as solar altitude (the angle of the sun above the horizon) and solar azimuth (the horizontal angle of the sun, i.e., the compass direction of a vertical line drawn from the sun straight down to the horizon).

- S**olar altitude and azimuth—**At higher sun angles, light may be cast more on the tops of structures, which can increase the brightness and contrast of the facility as seen from elevated viewpoints. At higher sun angles, shadows are diminished, and the landscape can take on a more washed-out appearance, with lower levels of contrast for more distant objects. Of course, solar azimuth also alters the amount and position of light on an object, interacting with the viewing geometry to determine whether structures in the landscape are frontlit (the side facing the viewer is fully illuminated by light coming from behind the viewer), backlit (the side facing the viewer is fully shaded because the object is between the viewer and the light source), or sidelit (the side facing the viewer is partly illuminated and partly shaded because the light is falling more or less perpendicular to the line of sight between the viewer and the object). Whether an object is frontlit, backlit, or sidelit can greatly increase or diminish its visibility, depending, in part, on the visual backdrop against which it is viewed. In general, backlighting from the sun will silhouette objects, making their contours prominent but concealing surface detail. Frontlighting reveals surface detail, texture, and color differences and causes objects to contrast more strongly with darker backdrops.

  Solar altitude and azimuth vary both during the course of the day and seasonally, sometimes causing facilities to vary dramatically in appearance and contrast at different times of day and at different times of year.

  Time of day—As the sun rises in the east, passes through the meridian at noon, and sets in the west, it will cause facilities to the east or west of viewers to switch from being backlit to frontlit or vice versa during the course of the day. Both conditions may result in high contrast with the visual backdrop, either because the backlit objects are silhouetted against the brightly sunlit background, or frontlit objects are viewed against the darker sky (or a ground backdrop) opposite the sun. During the middle parts of the day, the high-angle sunlight strikes vertically oriented objects (e.g., wind turbines) obliquely and with diminished shadows, so contrast is somewhat lower.

  Facilities south or north of viewers may be sidelit at the beginning and end of the day, depending upon the season (see below). For viewers north of a facility, the facility will likely be backlit in the middle part of the day. For viewers south of a facility, it will generally be frontlit in the middle of the day.

  Seasonal variation—In the northern hemisphere during the fall and winter, the sun is in the southern sky the entire day; in the spring and summer, the sun rises and sets in the northern sky but is in the southern sky most of the day (see Figure B-3). At the beginning of spring and fall, the sun rises and sets near due east and due west. It is only in spring and summer, in the early morning and late afternoon, that the sun is located in the northern sky for a significant portion of the day. This means that throughout the year, except for the early mornings and late afternoons in spring and summer, a facility will appear completely or mostly frontlit to viewers south of the facility. It will be fully illuminated, with little shadowing evident. If the backdrop is light, contrast may be low. If the backdrop is dark, contrast may be high. Viewers north of a facility will almost always see the facility components completely or mostly backlit (shaded), and in winter, with the sun low in the southern sky, components with a sky backdrop may be silhouetted and show strong contrasts. If the backdrop is dark, the components may be difficult to discern. Viewers to the east or west of a facility will tend to see the facility more sidelit in winter than in summer.

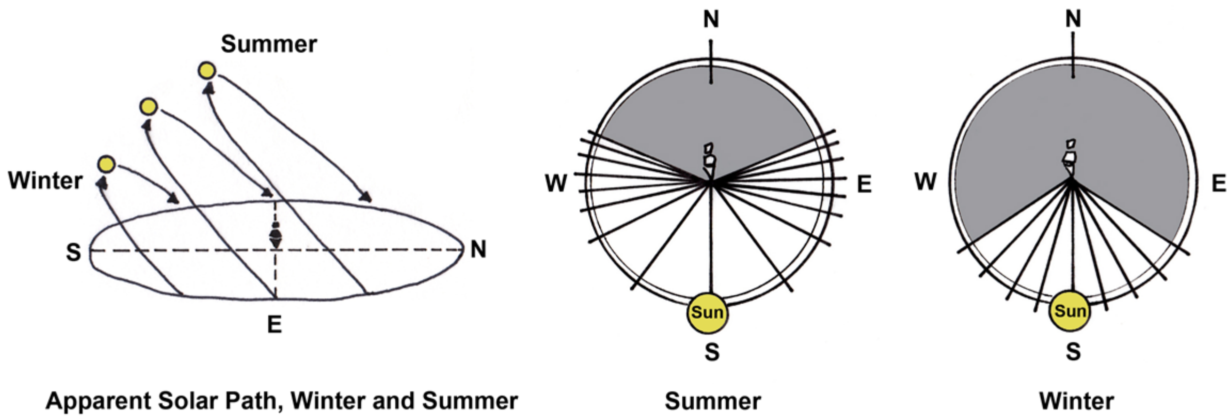


Figure B-3. Apparent Solar Path and Locations of Sunrise and Sunset in Summer and Winter in the Northern Hemisphere (The sun rises and sets north of due east and west only in summer, and the sun is higher in the sky in summer than in winter. In winter, the sun rises and sets south of due east and west and is lower in the sky than in summer.) (Credit: Argonne National Laboratory)

- **Weather and Climate—**Local weather can greatly affect the visibility and appearance of facilities, primarily by changing the amount and quality of sunlight falling on the facility. A cloud passing in front of the sun changes the light on both the facility and the backdrop and often causes a sudden drop in contrast that may make distant facilities difficult to see. When the sun "pops out" from behind a cloud, there may a rapid increase in contrast and consequently visibility. Thus in some circumstances, weather adds a dynamic quality to the viewing experience.

  Weather-induced lighting changes can have dramatic effects on the contrast levels associated with wind turbines, and especially for solar facilities that utilize mirrors or heliostats. White wind turbines may appear to be starkly white in bright sunlight, but a medium or even a dark gray when shaded. Because solar mirrors and heliostats typically reflect the sky above them, they will assume the hue, value, and chroma of the blue sky or clouds, if present, and thus they can appear to be a solid blue, a dull gray, a brilliant white, a dappled blue and white, or even green as they reflect nearby vegetation. Their appearance may change rapidly and dramatically as clouds pass by.

  Climate will also affect facility visibility and contrast. Regions with sunnier skies and dryer air will, on average, experience higher levels of visual contrast and longer visibility distances for renewable energy facilities than will regions with less sunny skies and higher humidity levels.

B.5 Atmospheric Conditions

Water vapor (humidity) and particulate matter (dust, air pollution, and other particles) within the air affect visibility in multiple ways. Particulate matter scatters and absorbs light coming from an object, which diminishes contrast and subdues colors. The nature and degree of these effects depends on particle type and density, distance between the viewer and viewed object, and lighting conditions, among other things. Atmospheric conditions may affect an object's visibility through alterations of sharpness, brightness, and color, and can have a substantial effect on project visibility, especially at longer distances. On humid days with high levels of dust or pollutants, distant facilities may not be visible at all, or may be much harder to see, with substantially lower contrast and indistinct structure edges.

The term "atmospheric perspective" refers to the decrease in contrast between an object and its background as distance increases. As distance increases, the colors of the object become less distinct and shift toward the background color, usually blue or gray, but potentially red at sunrise or sunset. Atmospheric perspective is an important cue for an observer to determine relative distance of objects in the landscape.

B.6 Distance

Distance affects the apparent size and degree of contrast between an object and its surroundings. In general, visual contrasts are greater when objects are seen at close range. If other visibility factors are held constant, the greater the distance, the less detail is observable and the more difficult it will be for an observer to distinguish individual features.

Research has shown that in clear, dry air, under favorable but not uncommon lighting conditions and viewing geometry, wind turbines in the western United States can be visible at distances exceeding 30 mi (Sullivan et al. 2012a), although they are very small at long distances. Because of generally lower air quality and higher humidity, visibility distances in the Midwest and eastern United States are likely lower. Offshore wind turbines have also been shown to be visible beyond 25 mi (Sullivan et al. 2013). Very limited research is available about the visual characteristics of solar facilities; however, even relatively small facilities have been determined to be visible beyond 20 mi (Sullivan et al. 2012b), and larger facilities will likely be visible at longer distances.

B.7 Viewing Geometry

Viewing geometry refers to the spatial relationship of the viewer to the viewed object (e.g., a renewable energy facility), including the *observer position* and the *bearing* of the view. Observer position refers to the viewer's elevation with respect to the viewed object: whether the viewer is elevated with respect to the facility and therefore looking downward at it, lower in elevation than the facility and therefore looking upward at it, or level with the facility and looking across it. These relationships are shown in Figure B-4. The bearing refers to the compass direction of the view from the viewer to the object.

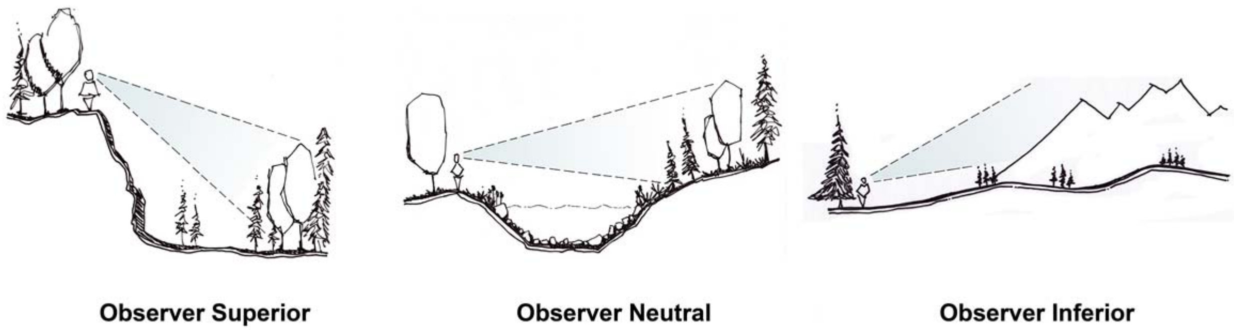


Figure B-4. Observer Position Descriptors Include Observer Superior (observer is at a higher elevation than the viewed object), Observer Neutral (observer is at the same elevation as the viewed object), and Observer Inferior (observer is at a lower elevation than the viewed object) (Credit: Argonne National Laboratory)

Both the observer position and the bearing may have important effects on facility visibility and contrast levels. The observer position is particularly important for solar facilities, which generally have low vertical profiles (i.e., the facility components are low in height), but the projects cover large areas. Views from ground level (observer neutral) may show the solar collector array as a thin line on the horizon, while views from elevated viewpoints (observer superior) often include the top surfaces of the structures in the facility, causing it to occupy more of the field of view and making the full areal extent and the regular geometry of the facility more apparent. For solar facilities, superior views also tend to show more of the often highly reflective solar arrays, which can greatly increase visual contrast, especially if glare or glinting occurs.

The bearing determines which side of the facility is in view (as shown in Figure B-5), and the angle of surfaces with respect to the viewer (e.g., whether wind turbine blade motion is seen face-on, where it can be quite noticeable, or seen from the side, where it may be nearly invisible). The bearing also interacts with the solar azimuth to determine whether the object is frontlit, backlit, or sidelit, and affects the potential occurrence of glare.

Movement of the viewer during the act of viewing a facility, such as viewing from an automobile on the highway or while walking down a trail, causes the viewing geometry to change, which can have dramatic effects on visibility and visual contrast. As rapidly changing viewing geometry changes the orientation of the line of sight to reflective surfaces, bright flashes of light, abrupt changes in apparent color, and abrupt changes in the patterns of light and shadows may result.

For moving viewers, the visual experience of wind facilities, and especially solar facilities, tends to be very dynamic, with major changes in the appearance of the facilities sometimes occurring over short periods of time or with small changes in viewer position.

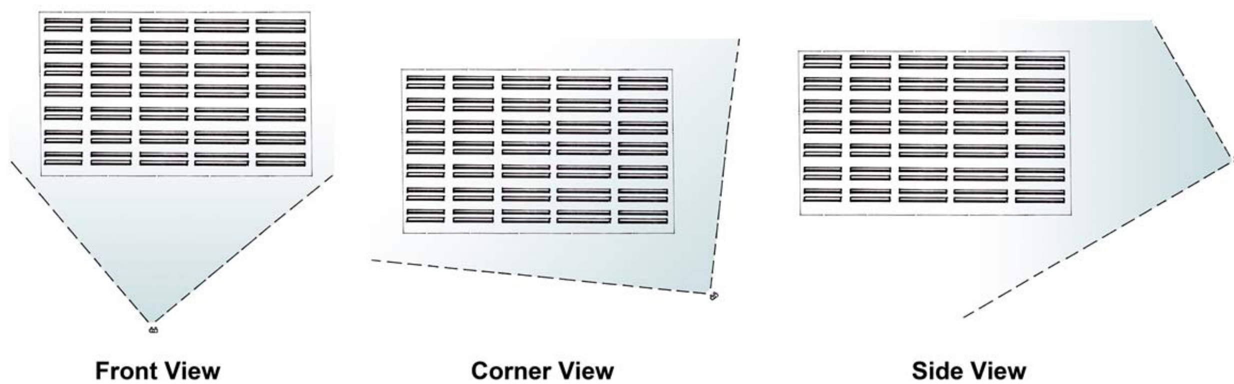


Figure B-5. The View Bearing Determines Which Side of The Facility Is In View, And The Angle Of Surfaces With Respect To The Viewer, Which Can Greatly Affect The Appearance Of The Facility (Credit: Argonne National Laboratory)

B.8 Backdrop

Objects that stand out against the visual backdrop (the background behind the facility) typically command a viewer's attention. As contrast between an object and its background is reduced, the ability to distinguish the object from the background diminishes. When the contrast becomes too small, the object will no longer be visible as separate from its background.

The backdrop against which the structures of a renewable energy facility are viewed affects their visibility. The degree to which visibility is affected depends on the color and textures of the structures and the backdrop, and the lighting falling on both. Light-colored or sunlit structures viewed against backdrops of dark vegetation or rock will show strong contrasts that can greatly extend their visibility, while dark or shaded structures against the same backdrop may nearly disappear. Conversely, dark or shaded structures against light backdrops, such as white or light gray clouds, pale blue skies, snow-covered slopes, or expanses of dried grasses, may cause strong contrasts, while light-colored or sunlit structures may be difficult to discern against these backdrops.

Because of their height, the visual backdrop of wind turbines may have a particularly large effect on their visibility. The strong vertical, stark white lines of sunlit turbines against dark mountain ridges or dark clouds may be especially conspicuous, while backlit turbines, and especially low-height solar facilities (e.g., photovoltaic [PV] facilities), may be substantially less affected. Sunlit water vapor plumes at solar facilities that use thermal power technology may stand out strongly against dark backdrops.

The texture or visual complexity of an object's backdrop may also affect the visibility of the object. While, in general, it is harder to distinguish objects against visually complex backgrounds, the flat, textureless surfaces of some man-made facilities can contrast strongly with visually complex, highly textured natural backgrounds, although texture effects tend to become less important at long distances.

B.9 Object Visual Characteristics

The inherent visual characteristics of the viewed object (e.g., a renewable energy facility) will obviously affect its visibility and the level of visual contrast it creates. The facility and structure size; the scale relative to other objects in view; the form, line, surface colors, and textures of the facility components; and any visible motion of the facility components will all affect the facility's apparent visual contrast.

- **Size:** Other things being equal, larger facilities with larger structures will obviously show increased visual contrasts relative to smaller facilities. Depending on the distance and the amount of the facility in view, a large wind facility can cover a significant portion of the horizontal field of view, even at long distances. Solar facilities, while generally smaller in size, are still quite large, and can occupy a substantial portion of the field of view at distances of several miles. Wind turbines and power towers are likely to be much taller than most other objects in the landscape and may seem out of scale with nearby objects in some situations.
- **Form and Line (Geometry):** Wind, solar, and transmission facilities typically have many rectilinear or regularly curved components which may contrast strongly with the forms and lines of predominantly natural landscapes.
- **Surface Color and Texture:** The color and surface texture of facility components can make them stand out or blend in with the visual backdrop. Darker colors tend to "recede" from the viewer, and lighter colors to "advance," so that lighter colors may appear to be closer to the viewer than darker background elements and may stand out against the background. Wind turbines effectively must be painted white for safety reasons (if turbines are not white, The Federal Aviation Administration [FAA] requires daytime lighting, which is rarely used). Transmission towers are often light colored, or may be made of highly reflective galvanized steel. The mirrored surface of solar collectors and the collecting surfaces of PV panels cannot be painted for performance reasons. Where structures cannot be painted or coated to reduce their color contrast, the color contrast may attract visual attention. Most facility components have smooth surfaces that may be highly reflective without special coatings to dull the finish, and if these components cause glinting or glare, it may greatly increase facility visibility at long distances.
- **Motion:** Motion is a strong attractant of visual attention, and facilities with moving components or other sources of visible motion are more likely to attract attention. An obvious example is the motion of wind turbines; the blade motion may strongly attract visual attention and has been shown to be visible at distances greater than 25 mi in clear air with good viewing conditions (Sullivan et al. 2012a). The mirrors of parabolic trough facilities, the heliostats of power towers, and, in some cases, the panels of PV facilities will track the daily course of the sun and thus slowly move. This movement is generally too slow to notice, but it can affect contrast levels and change the appearance of the facility. Water vapor plumes from cooling towers or gas boilers are also sources of visual contrast associated with motion. In some lighting situations, especially if viewed against dark vegetation or mountain ridges, the plumes can be visible for miles.

- **Hazard navigation and safety/security lighting**: All utility-scale solar and wind facilities have at least some lighting for facility safety and security, and where facilities include tall structures or are located in water, aviation obstruction lighting and/or marine navigation lighting will also be used. While lighting requirements vary widely by facility type, in general, lighting has a major effect on visibility of facilities at night, and in some cases during the day, if, for example, white flashing strobe lights are used. Several studies of wind and solar facility visibility have included observations of facility lighting in both day and nighttime settings (Sullivan et al. 2012a,b; Sullivan et al. 2013; Sullivan et al. 2014). These studies found the synchronized flashing of aviation obstruction lighting on an onshore wind facility was plainly visible at 36 mi and was judged likely to be visible at longer distances; on offshore wind facilities in the United Kingdom (U.K.), the lighting was observed as far as 25 statute miles (Sullivan et al. 2013). The U.K. study found marine hazard navigation lighting to be visible as far as 13 statute miles from an elevated onshore viewpoint. Solar facility lighting at small parabolic trough and PV facilities was observed at night at distances of 13 mi, but judged likely to be visible at longer distances. In daytime observations, multiple flashing white strobe lights on a large power tower were faintly visible at approximately 22 mi, clearly visible at 18 mi, and added substantially to the visual contrast of the facility at approximately 10 mi.

B.10 References

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Sullivan, R., et al. 2014. “Utility-Scale Solar Energy Facility Visual Impact Characterization and Mitigation Project Final Report.” Argonne National Laboratory, Argonne, Ill.

Appendix C: Visual Impact Analysis Checklists

This appendix includes three checklists that contain items that ideally should be included in a visual impact assessment (VIA): a checklist for topics and items that should be covered in the VIA as a whole, and checklists for both best management practices and visual simulations for impact avoidance, reduction, and mitigation. The checklists are intended to be used to quickly document the completeness and quality of a VIA under review. Users may compare the checklists against the assessment document to note the presence or absence of items on the checklists within the VIA. If desired, for the analysis and simulation checklists, users may rate the quality of the item as presented in the assessment and add notes about each item.

The checklists are designed for use as electronic documents, but may be adapted for use as paper documents.

Visual Impact Analysis Checklist

P = Poor; F = Fair; G = Good; E = Excellent

Guide Page Reference	Visual Assessment Requirement	Completeness of Assessment				Quality of Assessment				Notes
		P	F	G	E	P	F	G	E	
	Plan of Development/Construction and Operations Plan									
N/A	Description of key project components									
N/A	Maps, diagrams, and illustrations of key components									
	Affected Environment									
28	Applicable laws, regulations, ordinances, and standards									
	Regional Setting Description									
29	Description of the physical environment									
29	Major land uses and human presence and activities									
29	Relevant existing land use, visual management, or scenic conservation plans or programs									
29	Regional map									
29	Photos of typical landscapes in region									
	Site and Project Setting Description									
30	Description of project site and setting									
30	Map of project site									
30	Photos of project site									

Guide Page Reference	Visual Assessment Requirement	Completeness of Assessment				Quality of Assessment				Notes
		P	F	G	E	P	F	G	E	
30	Scenic quality description									
30	Documented visual/scenic resources									
30	Sensitive viewing location descriptions									
	Area of Potential Effect (APE)									
31	Appropriate distance for APE									
32	Rationale for selected APE									
	Visibility Analysis									
32	Methodology description									
32	Viewshed analysis									
32	Elevation data									
	KOP Selection and Description									
34	KOP selection									
34	KOP description									
	Viewer Information									
35	Numbers of viewers description									
35	Frequency and duration of views description									
35	Viewer familiarity description									
35	Viewer activities description									

Guide Page Reference	Visual Assessment Requirement	Completeness of Assessment				Quality of Assessment				Notes
		P	F	G	E	P	F	G	E	
35	Viewer concern description									
	Environmental Consequences									
38	Impact assessment scope and methodology									
	Visual Characteristics of Proposed Project									
38	Description of visual characteristics of project components									
38	Description of visual characteristics of ancillary components									
39	Impacting activities by project phase									
	Presentation of Simulations									SEE VISUAL SIMULATION CHECKLIST
	Contrast Assessment									
38	Description of contrasts from main facility components									
38	Description of contrasts from ancillary components									
42	Description of contrasts from transitory effects, e.g., seasonal, diurnal, glinting, glare, plumes									
39	Description of contrasts from human activities									
39	Contrasts described for all project phases									
39	Contrast assessment uses appropriate design terminology									

Guide Page Reference	Visual Assessment Requirement	Completeness of Assessment				Quality of Assessment				Notes
		P	F	G	E	P	F	G	E	
40	Contrast assessment uses defined and appropriate magnitude descriptions, e.g., weak, moderate, strong									
40	Contrast assessment uses appropriate agency methods (where applicable)									
42	Contrast assessment includes expected duration of contrasts									
42	Contrast assessment discusses effects of visibility factors									
	Impact Assessment									
68	Description of direct impacts on scenic qualities and landscape character									
68	Description of direct impacts on potential viewers' perceptions and behaviors									
69	Impact assessment uses defined and appropriate magnitude descriptions, e.g., low, moderate, high									
69	Impact assessment uses appropriate agency methods (where applicable)									
70	Description of impacts from alternatives									
70	Description of indirect impacts									
71	Description of cumulative impacts									
72	Description of irreversible or irretrievable commitments of visual resources									
	Mitigation Measures									SEE VISUAL IMPACT MITIGATION CHECKLIST

Visual Mitigation Measures Checklist

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
	Mitigation Planning								
6.1.1	Ensure that qualified individuals conduct and review impact analyses and mitigation plans.								
6.1.2	Use appropriate methods and data for visual impact analysis and mitigation planning and design.								
6.1.3	Incorporate stakeholder input into the siting and design and mitigation planning processes.								
6.1.4	Consult the applicable VRI and VRM Class designations.								
6.1.5	Conduct a thorough assessment of existing and potentially affected visual resources.								
6.1.6	Develop spatially accurate and realistic photosimulations of project facilities.								
6.1.7	Develop a visual resource monitoring and mitigation compliance plan.								
6.1.8	Develop a decommissioning and site reclamation plan.								
6.1.9	Hold a preconstruction meeting to coordinate the mitigation strategy.								
6.1.10	Discuss visual mitigation objectives with equipment operators.								
6.1.11	Use off-site mitigation.								
	Siting and Design								
6.2.1	Site facilities and ROWs outside sensitive viewsheds or as far as possible from sensitive viewing locations.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
6.2.2	Site ROW crossings to minimize impacts on linear KOPs.								
6.2.3	Site projects away from visually prominent landscape features.								
6.2.4	Site facilities to avoid night-sky impacts on sensitive locations.								
6.2.5	Site facilities and components in existing clearings.								
6.2.6	Site facilities in previously developed or disturbed landscapes.								
6.2.7	Site and design facilities to repeat the form, line, color, and texture of the existing landscape.								
6.2.8	Site facilities in areas suitable for reclamation.								
6.2.9	Minimize the number of facility structures.								
6.2.10	Co-locate linear features in existing ROWs or corridors.								
6.2.11	Avoid siting linear features in centers of valley bottoms and on ridge tops.								
6.2.12	Avoid sky-lining.								
6.2.13	Site linear facilities along natural lines within the landscape.								
6.2.14	Avoid siting roads on side slopes.								
6.2.15	Site facility components to minimize cut and fill.								
6.2.16	Avoid siting staging and laydown areas in visually sensitive areas.								
6.2.17	Bury underground utilities along roads.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
	Structure Design and Material Selection								
6.3.1	Use low-profile structures and tanks.								
6.3.2	Custom design structures in key areas.								
6.3.3	Consider use of alternative components.								
6.3.4	Use natural-looking landform, vegetative, or architectural screening.								
6.3.5	Minimize the use of signs and make signs visually unobtrusive.								
6.3.6	Avoid unnecessary use of gravel/paved surfaces.								
6.3.7	Use rounded road cut slopes.								
6.3.8	Use monopole and lattice electric transmission towers appropriately.								
	Materials Surface Treatments								
6.4.1	Require a site study for color and texture selection.								
6.4.2	Materials and surface treatments should repeat the form, line, color, and texture of the surrounding landscape.								
6.4.3	Consider seasonal changes and seasons of heaviest use in choosing materials colors and textures.								
6.4.4	Color treat structures to reduce contrasts with existing landscape.								
6.4.5	Use non-reflective materials, coatings, and/or paint.								
6.4.6	Select surface treatment colors from the BLM Standard Environmental Colors Chart.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
6.4.7	Test color selections.								
6.4.8	Color treat grouped structures using the same color.								
6.4.9	Color-treat exposed rock faces.								
6.4.11	Use camouflage and/or disguise strategies for close KOPs in highly sensitive viewsheds.								
6.4.12	Maintain painted, stained, or coated surfaces properly.								
	Lighting								
6.5.1	Prepare a lighting plan.								
6.5.2	Use AVWS technology for hazard lighting on structures taller than 200 ft.								
6.5.3	Use full cutoff luminaires.								
6.5.4	Direct lights properly to eliminate light spill and trespass.								
6.5.5	Use amber instead of bluish-white lighting.								
6.5.6	Minimize lighting usage during construction and operations.								
6.5.7	Use vehicle-mounted lights or portable light towers for nighttime maintenance.								
	Avoiding Unnecessary Disturbance								
6.6.1	Minimize project footprint and associated disturbance.								
6.6.2	Avoid unnecessary road improvements.								
6.6.3	Use penalty clauses to protect high-value landscape features.								
6.6.4	Confine construction activities and facilities to pre-defined areas.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
6.6.5	Provide construction personnel with avoidance area maps.								
6.6.6	Do not apply paints or permanent discoloring agents to rocks or veg.								
6.6.7	Require overland driving where re-contouring is not required.								
	Soil, Erosion, and Dust Management								
6.7.1	Implement dust and wind erosion control measures.								
6.7.2	Implement erosion and sediment control measures.								
6.7.3	Implement temporary and/or permanent soil stabilization measures.								
6.7.4	Strip, stockpile, and stabilize topsoil for re-spreading.								
6.7.5	Segregate topsoil and reapply to disturbed areas.								
	Vegetation Management								
6.8.1	Prepare a reclamation plan.								
6.8.2	Design vegetative openings to mimic natural openings.								
6.8.4	Preserve existing vegetation.								
6.8.5	Use retaining walls, berms, fences, and markings to protect trees and other scenic features.								
6.8.6	Avoid slash piles in sensitive viewing areas; chip slash for mulch to hide fresh soil.								
6.8.7	Mulch cleared areas, furrow slopes, and use planting holes.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
6.8.8	Use pitting and vertical mulching to facilitate revegetation and discourage vehicle traffic.								
6.8.9	Re-vegetate using salvaged native plants and approved, weed-free seed mixes.								
6.8.10	Transplant vegetation from cleared areas.								
6.8.11	Monitor and maintain revegetated areas until vegetation is self-sustaining.								
	Reclamation								
6.9.1	Review predevelopment visual conditions after construction.								
6.9.2	Begin site reclamation during construction and operations, immediately after disturbances.								
6.9.3	Re-contour disturbed areas to approximate natural slopes.								
6.9.4	Scarify/roughen cut slopes and recontoured areas.								
6.9.5	Salvage and replace rocks, brush, and woody debris.								
6.9.6	Sculpt and shape bedrock landforms.								
6.9.7	Remove two-track roads.								
6.9.8	Close and remediate unused access roads.								
6.9.9	Remove above-ground and near-ground structures.								
6.9.10	Remove or bury gravel and other surface treatments.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
	Good Housekeeping								
6.10.1	Develop “housekeeping” procedures.								
6.10.2	Maintain a clean worksite.								
6.10.3	Prohibit on-site burning.								
6.10.4	Use exit tire washes and vehicle tracking pads to reduce the tracking of sediment onto roads.								
6.10.5	Remove or avoid slash pile.								
6.10.6	Clean off-road equipment.								
6.10.7	Remove stakes and flagging.								
6.10.8	Use fabric-covered fences to conceal material storage yards and laydown yards.								
6.10.9	Actively maintain operating facilities.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
3.1	Consider topography when siting wind turbines.								
3.2	Cluster or group turbines to break up overly long lines of turbines.								
3.3	Create visual order and unity among turbine clusters.								
3.4	Site wind turbines to minimize shadow flicker.								
3.5	Relocate turbines to avoid visual impacts.								
3.6	Use AVWS technology to reduce night-sky impacts.								
3.7	Create visual uniformity in shape, color, and size.								
3.8	Use fewer, larger turbines.								
3.9	Use non-reflective coatings on wind turbines and other facility components.								
3.10	Prohibit commercial messages and symbols on wind turbines.								
3.11	Keep wind turbines in good repair.								
3.12	Clean nacelles and towers.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
NA[a]	Site developments away from sensitive visual resource areas and/or areas with limited visual absorption capability or high scenic integrity in order to reduce perceived visual impact.								
NA	Where possible, site developments in already industrialized and developed seascapes.								
NA	Site developments such that intervening headlands screen views from sensitive landscapes/seascapes.								
NA	Site facilities so that they are not framed by landforms in views from highly sensitive inland scenic vistas or other sensitive areas.								
NA	Facility layout should be designed to minimize the horizontal spread of the layout from shore.								
NA	Wind turbine generators should be uniform in shape, color, size of rotor blades, nacelles, and towers.								
NA	Tubular tower designs should be utilized where possible.								
NA	Use non-reflective coatings on wind turbines and other facility components.								
NA	Prohibit commercial messages and symbols on wind turbines.								
NA	Keep wind turbines in good repair.								
NA	Lighting should be minimized to the extent possible.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
3.6	Use AVWS technology to reduce night sky impacts.								
NA	Site facilities as far from shore as possible.								

[a] NA = not applicable. Recommended visual mitigation measures for offshore wind energy activities can be found in the *Guide to the OCS Alternative Energy Final Programmatic Environmental Impact Statement (EIS)* at http://www.boem.gov/Renewable-Energy-Program/Regulatory-Information/Guide-To-EIS.aspx.

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
4.1	Develop a glint and glare assessment, mitigation, and monitoring plan.								
4.2	Use dry-cooling technology for CSP facilities.								
4.3	Site and operate solar collectors to avoid off-site glare.								
4.4	Screen solar collectors to avoid off-site glare.								
4.5	Use color-treated solar collectors and support structures.								
4.6	Maintain color-treated surfaces of solar collectors.								
4.7	Avoid complete removal of vegetation beneath solar collector array.								
4.8	Prohibit commercial messages and symbols on solar power towers and solar collector arrays.								

BLM BMP Guide #	Best Management (BMP) Description	In Visual Assessment	In Plan of Development	N/A	Discussed but Eliminated	Being Considered	Being Implemented	NPS Priority	Notes
6.4.10	Color treat transmission towers to reduce contrasts with existing landscape.								
6.6.8	Use air transport to erect transmission towers.								
6.8.3	Use partial ROW clearing and feather edges of transmission ROWs.								

Visual Simulation Checklist

Guide Page Reference	Visual Simulation Requirement	Provided in Text or Simulation		Notes
		Y	N	
	General			
81	Simulation format(s) is/are appropriate for type and scale of project.			
82	All substantial contrast sources from normal operations are depicted in simulations, e.g., water vapor plumes, reflections from structures.			
82	Simulations depict conditions that would be experienced in season of high visitor use of KOP, supplemented by simulations of other seasons of use, as appropriate.			
82	Simulations accurately reflect current project design.			
82	Daytime simulations depict sunny conditions with good visibility, supplemented by other conditions, as appropriate.			
82	Night-sky impact simulations are provided if project creates substantial night-sky contrasts.			
82	Glare depicted in simulations where applicable.			
	KOP Selection			
82	KOPs selected for simulation are representative of range of contrasts.			
90	KOPs selected for simulation include the most important viewpoints.			
90	Number of KOPs selected for simulations is appropriate.			
90	KOPs selected for simulation neither under-or over-represent contrasts.			

Guide Page Reference	Visual Simulation Requirement	Provided in Text or Simulation		Notes
	Field Notes/Camera			
83	Identified camera make and model.			
83	Identified lens make and model.			
83	Identified camera (viewer) height.			
83	Identified date and time of photograph.			
83	Provided description of weather conditions.			
83	Provided description of viewing location.			
83	Identified GPS Coordinates of photograph.			
83	Identified elevation of viewpoint.			
83	Identified solar azimuth/elevation.			
83	Identified original and 35-mm film equivalent focal length.			
83	Identified horizontal and vertical field of view.			
81	Indicated single frame or panoramic photograph.			
84	Submitted original single frame photographs with metadata.			
	Simulation Methodology and Documentation			
84	Identified simulation preparer.			
84	Described simulation technique, including process steps and software used.			
84	Described any manual adjustments, e.g., edge blending, position adjustments, shading.			

Guide Page Reference	Visual Simulation Requirement	Provided in Text or Simulation		Notes
A-2	Used 10-m elevation data (if available) or better.			
A-2	Incorporated earth curvature.			
A-2	Incorporated atmospheric refraction.			
82	Identified known and possible sources of error.			
	Simulation Quality			
81	Simulation shows adequate level of detail to show all important contrasts.			
81	Simulation includes enough of landscape surrounding project to provide adequate visual context for judging project's impact on landscape setting.			
83	Photos/simulations sharp and properly exposed.			
82	All facility elements that would be visible are shown.			
82	Facility elements appear to be in correct locations and orientations.			
91	Screening elements such as vegetation and structures that would be present or removed if the project were built are properly depicted.			
91	Simulation is free of distracting or screening elements in immediate foreground that would not normally be seen from KOP.			
82	Facility elements appear to be shown at correct size and proper visual perspective.			
82	Project elements colored and shaded properly.			

Guide Page Reference	Visual Simulation Requirement	Provided in Text or Simulation		Notes
92	Distance and atmospheric effects properly depicted, i.e., distant objects seem a more dull or gray/blue cast in keeping with nearby landscape features.			
92	Contrast range depicted reasonably, accurately reflects contrast that would be experienced in the field.			
93	Sun angle as indicated by surface illumination and shadows appears to be correct for date and time of simulation.			
93	Facility component shadows match those of other objects in photo, or otherwise appear to be correct for sun angle.			
92	Facility components blend seamlessly with background, with edges that are neither overly sharp nor overly blended.			
	Simulation Presentation			
83	Identified project, alternative, and KOP.			
83	Provided supplementary information for simulation on a separate sheet.			
84	Provided facility map with major landscape features and KOPs.			
83,84	Specified bearing/horizontal angle of view for each KOP/simulated view.			
84	Provided graphic representations of bearing/horizontal angle of view for each KOP/simulated view.			
84	Identified lighting conditions, i.e., frontlit, sidelit, backlit.			
84	Identified distance to nearest facility element.			

Guide Page Reference	Visual Simulation Requirement	Provided in Text or Simulation		Notes
84	Specified correct viewing distance at all display sizes provided.			
83	Simulations reproduced at a size large enough to be comfortably viewed from the appropriate specified viewing distance.			

Visual Simulation Overall Assessment					
Completeness Assessment:	Poor	Fair	Good	Excellent	Notes:
Quality Assessment:	Poor	Fair	Good	Excellent	Notes:

Appendix D: Renewable Energy and Electric Transmission Visibility Studies

This appendix summarizes various studies sponsored by different federal agencies to identify the visual characteristics of onshore and offshore wind, solar, and electric transmission facilities, and to investigate the effects of distance and other visibility factors on visual contrasts associated with the facilities. The results of these studies are discussed in Section 4.2.2 of this document.

D.1 Onshore Wind Turbine Visibility Study

In a study sponsored by the U.S. Department of the Interior, Bureau of Land Management (BLM), Sullivan et al. (2012a) conducted 377 observations of five wind facilities in Wyoming and Colorado under various lighting and weather conditions. The facilities ranged in size from 74 to 273 turbines, with blade tip heights (distance from the tower base to the tip of a blade pointed straight up) of up to 383 ft. One of the facilities was found to be visible to the unaided eye at distances up to 36 mi under optimal viewing conditions, and frequently visible at distances exceeding 30 mi. Under favorable viewing conditions, the wind facilities were judged to be major foci of visual attention at up to 12 mi in the day, and likely to be noticed by casual observers at up to 23 mi.

At night, the synchronized flashing of aviation obstruction lighting was plainly visible at 36 mi before topography cut off the view, but the light was judged likely to be visible at longer distances. Turbine blade movement was often visible up to 24 mi.

The study recommended that an appropriate area for visual impact analyses for moderately sized turbines in moderately sized wind energy facilities in western U.S. landscapes would be 30 mi, that, in some cases, the facilities would be unlikely to be missed by casual observers at up to 20 mi, and that the facilities could be major sources of visual contrast at up to 10 mi.

D.2 Offshore Wind Turbine Visibility Study

In a study sponsored by the U.S. Department of Energy (DOE), Sullivan et al. (2013a) assessed the visibility of 11 utility-scale wind facilities off the coast of the United Kingdom. The facilities ranged from 25 to 140 turbines, with blade tip heights ranging 351 to 502 ft. The study showed that under favorable but not exceptional viewing conditions, moderately sized offshore wind facilities may frequently be visible at distances exceeding 22 statute miles in the daytime, and in this study, were visible at a maximum distance of 27 statute miles. At distances up to 10 statute miles, the wind farms were often a major focus of visual attention and a strong source of visual contrast. The study also found that the wind farms would likely be noticed by casual observers up to a distance of approximately 18 statute miles for a 100-turbine facility, and about 15 statute miles for facilities with 25 to 48 turbines. Blade motion was often visible at distances up to 21 statute miles and was frequently cited as a major contributor to visual contrasts at distances up to 10 statute miles. At night, the red flashing aviation obstruction lighting was visible as far as 25 statute miles. Amber marine navigation lighting was visible out to 13 statute miles, from an elevated viewpoint.

The study also included observations where one offshore wind facility relatively far from shore was visible beyond and through a closer onshore facility, so that from an onshore viewing location, the two sets of turbines appeared to be “mixed.” The observers found that the “mixed” turbines attracted and held visual attention. The study observers also encountered several local residents that complained about seeing multiple non-overlapping wind facilities that made it difficult to view the sea without having to look at wind turbines, another type of cumulative visual impact.

D.3 Solar Energy Facility Visibility Studies

In studies sponsored by the BLM and National Park Service (NPS) from 2010 to 2012 and by DOE in 2013, Sullivan et al. (2012b; Sullivan et al. 2013b) made several hundred observations of various utility-scale facilities in Nevada, California, and Spain. These studies focused on identifying the visual characteristics of the various solar technologies and identifying associated sources of visual contrast, especially glare. A study sponsored by DOE further characterized visual contrast from solar facilities based on observations of various facilities in Nevada and Colorado, and also investigated mitigation feasibility.

Sullivan et al. (2012b) observed two very small power towers (5- and 20-MW, respectively) in the United States and in Spain. In both cases, the reflected light from the receiver was visible at 20 mi, but views from farther distances were judged to be likely. In separate observations made in Spain, a streaming effect from sunlight reflected off dust particles was observed at 5 mi distance from a 20-MW operating power tower facility. As part of the DOE study, Sullivan observed the *unlit* tower of a large-scale power tower facility under construction in the United States (consisting of three 100-MW towers) to be faintly visible at a distance of 35 mi (Sullivan et al. 2013b).

Sullivan et al. (2012b) repeatedly observed strong glare at distances exceeding 3 mi from a small parabolic trough facility in Nevada. Glare was observed at various times throughout the day at different times of the year and appears to be a daily occurrence. It was observed at locations east, west, and north of the facility, and some observers found the glare to be painfully bright at times, enough that they were forced to close their eyes instantly when looking at the facility.

Sullivan observed glare from heliostats surrounding a large power tower under construction in California at a distance of 10 mi and found it annoyingly bright, but not painfully so (Sullivan et al. 2013b). The glare was judged to be a major source of visual contrast that would strongly attract and hold attention.

Sullivan et al. (2013b) observed very bright reflections from a concentrating photovoltaic (PV) facility at a distance of 26 mi. The reflections were not bright enough to be considered glare; however, they were judged to be a major focus of visual attention.

In all the observations of glare described above, it was noted that the occurrence of glare was highly dependent on viewing geometry, that is, the relative positions of the observer, the glare-causing elements of the facility, and the direction of the sunlight. The glare was observed to increase or decrease dramatically in just a few seconds or minutes, whether in response to slight changes in the observer’s position, or because of changes in mirror orientation as the heliostats tracked the sun.

Sullivan et al. (2012b) made a few observations of a parabolic trough and a PV solar facility at night and found the facility lighting to be visible at a distance of 13 mi, and judged it likely to be visible somewhat farther. In daytime observations made as part of the ongoing DOE study, multiple flashing white strobe lights on a large power tower were faintly visible at approximately 22 mi, clearly visible at 18 mi, and added substantially to the visual contrast of the facility at approximately 10 mi (Sullivan et al. 2013b).

Sullivan et al. (2012b) observed a 600-acre PV facility at a distance of 22 mi, but contrast at that distance was low. The solar collector arrays at multiple non-tracking thin-film PV facilities were observed to shift color dramatically from black through various shades of blue to white and then back to black when observed from vehicles traveling parallel to the orientation of the panels (i.e., north–south), as shown in Figure 4.2-7.

D.4 Electric Transmission Visibility Studies

Jones and Jones (1976) conducted a study of visibility of a range of lattice tower transmission lines and an H-frame transmission line in a range of landscape settings in the northwestern United States. In addition to examining the visibility of the transmission towers, the study also examined the visibility of cleared rights-of-way (ROWs) in forested landscapes. The study results indicated that transmission tower visibility is highly dependent on the color and visual complexity of the background. Towers viewed against sky backdrops were visible at longer distances and were more visible at a given distance than towers viewed against a ground backdrop. A dark and more visually complex background, such as rough textured shrubs, was better able to "mask" the towers than more uniform, finely grained, and lighter backgrounds such as dried grasses. The study also found that visible access roads and cleared ROWs in forested landscapes could greatly increase visibility; in some instances, the cleared ROW might be visible even though the towers were not. The study reported an observation of a cleared ROW at 40 mi and individual towers at distances of 23 mi, but in these observations, the objects were at the limit of visibility, that is, barely discernible. The study recommended much smaller areas of impact analysis, ranging from 1.4 to 8.2 mi depending on the tower size and landscape setting for transmission facilities not requiring cleared ROWs. Far larger areas of analysis were recommended for transmission facilities with cleared ROWs, ranging from 1.5 mi for an 80-ft ROW to 24.3 mi for a 640-ft ROW.

The results of a study of lattice, monopole, and H-frame transmission facilities by Sullivan et al. (2014) in grasslands in Idaho and desert areas in California and Nevada confirms many of the finding of the Jones and Jones (1976) study. A total of 232 observations from 123 study observation points were made in a variety of lighting and weather conditions. Transmission facilities viewed against sky backdrops were found to be visible at much longer distances and to be substantially more visible at a given distance than those viewed against ground backdrops. Approximately 10% of the observations of 500-kV transmission towers were at distances beyond 10 mi. Skylined facilities with 500-kV lattice towers were observed to be just barely visible to the unaided eye at a maximum distance of 17 mi, and lattice towers were visible beyond 10 mi in 17 observations. Beyond 11 mi, only skylined transmission towers were visible. The skylined facilities were judged to be noticeable to casual observers at distances of up to 10 mi, but in many cases, the 500-kV lattice facilities only became easily visible at much shorter distances. They were judged to be major sources of visual contrast at distances of up to 3 mi when skylined or viewed against a light colored backdrop, such as dried grasses. Visibility of 500-kV lattice tower facilities with ground backdrops was more limited, particularly where there was low contrast between the towers and conductors and the backdrop, such as when shaded or backlit towers were viewed against darker and more textured backgrounds such as shrublands or rock.

Facilities with 500-kV monopole towers were visible at distances up to 11 mi but might have been visible at longer distances had topography permitted. Their visibility at shorter distances was generally similar to that of lattice tower facilities; monopoles, however, were judged to be more visible than lattice towers at the shortest distances.

Skylined 230-kV H-frame towers were observed at distances up to 8 mi, but facilities with ground backdrops were not visible beyond 5 mi. They were noticeable to casual observers at distances of up to 3.5 mi. They were judged to be major sources of visual contrast at distances of up to 1.5 mi, but more typically created strong contrasts at distances of up to about ½ mi.

D.5 References

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