ACP presentation before the Kansas Senate Select Committee on Wind Turbine Lighting

October 27, 2022

Overview of Light Mitigation Technologies and FAA Regulation

To be covered in this presentation:

1. Federal Aviation Administration (FAA) Statutory Authority Over Wind Turbine Lighting
2. FAA Lighting and Marking Advisory Circular Requirements
3. FAA Review and Approval of Wind Turbine Lighting Plans
4. Aircraft Detection Lighting Systems (ADLS) and Status of FAA Approval
5. Light Dimming Systems and Status of FAA Approval

The Wind Industry Takes Community Concerns about Lighting Seriously; has Proposed Measures to Reduce Impacts

- Over the years, the wind industry has encouraged the FAA to take steps to reduce the visual impact of turbine lights on communities, while still ensuring visibility for pilots to maintain aviation safety.
- The FAA has been receptive to many of these suggestions –
  - Depending on project details, generally not requiring every turbine in a wind farm to be lit;
  - Requiring simultaneous flashing;
  - Allowing aggregation of lighting plans with nearby wind farms to reduce overall lighting impacts; and,
  - Evaluating technologies to reduce lighting effects.

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FAA Authority Over Wind Turbine Lighting

- Federal law, Title 49 United States Code Section 40103 (49 USC 40103), provides the Federal Aviation Administration (FAA), with "exclusive sovereignty" over U.S. airspace and provides direction to the FAA to issue regulations related to "navigating" and "protecting" aircraft, among other purposes.
  - Courts have struck down as unconstitutional efforts where state or local governments attempt to regulate airspace issues in potential conflict with the FAA. See, for example, *Big Stone Broadcasting, Inc. v. Lindbloom*, 161 F. Supp. 2d 1009 (D.S.D. 2001).
- Title 14 U.S. Code of Federal Regulations Part 77 (14 CFR Part 77) are the FAA's rules that govern review of proposed structures that could represent an obstruction to air safety and navigation.
  - These regulations require anyone who plans to construct or alter a structure that exceeds 200 feet (61 meters [m]) above ground level (AGL) to notify the FAA of their plans by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1).
  - One of the purposes of these forms is to "determine appropriate marking and lighting recommendations…"
  - As a part of the 7460-1 notification filed for each individual turbine, the developer can request a preferred lighting and marking plan, however, the final determination on what is allowed or not allowed is up to the FAA.
  - The FAA defaults to requiring each turbine to be lit, but once a final layout is complete, the developer can request a re-evaluation of the lighting and marking plan and the FAA may reduce the number of turbines required to be lit

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FAA Lighting and Marking Advisory Circular

- The FAA Lighting and Marking Advisory Circular provides detailed lighting and marking requirements for various potential structures, including wind turbines.
- The most recent version is AC 70/7460-1M dated November 16, 2020.
- Chapter 10 is specific to Aircraft Detection Lighting Systems (ADLS).
- Chapter 13 is specific to wind turbines.
  - The FAA notes, “Each wind turbine farm is unique, therefore it is important that a lighting plan is developed that provides sufficient safety for air traffic.” In other words, one-size does not fit all.
  - The FAA considers factors like proximity to airports, visual flight rule (VFR) routes, local flight activity, and terrain when considering individual wind farm lighting plans.

FAA Requirements Specific to Wind Turbines in AC70/7460-1M

- Each wind turbine must be painted pure white (“preferred color”) to light grey (“darkest acceptable”) to ensure daytime visibility to pilots; daytime lighting of wind turbines is not required.
- Nighttime obstruction lighting should consist of FAA L-864 aviation red flashing strobe light, or pulsed obstruction lights, which provide pilots with the highest visibility.
- FAA varies other requirements by turbine height:
  - For wind turbines with tip heights below 500 ft (152.4 m) AGL, obstruction lights can be omitted provided there are no unlit gaps greater than ½ statute mile (SM; 804 m)
  - For all wind turbines at or greater than 500 ft (152.4 m) AGL, each wind turbine should be lit with two FAA L-864 red flashing lights on the nacelle, regardless of their location within a wind farm.
  - All wind turbines at or greater than 699 ft (213 m) should be lit with an additional level of FAA L-810 lights located at a point on the tower midway between the top of the nacelle and ground level.
  - These additional lights are required to flash in unison with the two L-864 red flashing lights located at the top of the nacelle.
- Regardless of turbine tip height, all lighting should be synchronized to flash simultaneously (e.g., within 0.05 second of each other) at a rate of 30 flashes per minute (fpm; +/- 3 fpm).

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Light Mitigation Technologies Overview

- Aircraft Detection Lighting Systems (ADLS)
  - FAA defines ADLS as “sensor-based systems designed to detect aircraft as they approach an obstruction or group of obstructions; these automatically activate the appropriate obstruction lights until they are no longer needed by the aircraft.”
  - Essentially, these are radar-activated lighting systems.
- Light Dimming Systems
  - These are also sensor-based systems, but rather than keeping the lights off, they dim the lights until an aircraft is approaching.
- Overview of FAA Review and Approval Process of Light Mitigation Technologies
  - The FAA does lab testing and flight testing of proposed light mitigation technologies to gauge pilot visibility and technology performance, the FAA then writes performance requirements that the technology needs to meet, and then certifies whether specific vendor technologies meet those performance requirements.

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Status of FAA Approval of Light Mitigation Technologies

- Aircraft Detection Lighting Systems (ADLS)
  - ADLS is the only light mitigation technology currently approved for use on wind turbines.
  - The FAA has written performance requirements for ADLS as detailed in Chapter 10 of the Lighting and Marking Advisory Circular.
  - The FAA has certified four individual vendor systems as meeting the performance requirements. However, one of those companies no longer exists.
  - **Even when the FAA has certified an ADLS as meeting the performance requirements, however, it does not mean a developer can automatically install it on any wind farm. The FAA approves deployment of ADLS on a "case-by-case basis."** (see next slide).
- Light Dimming Systems
  - These are also sensor-based systems, but rather than keeping the lights off, they dim the lights until an aircraft is approaching.
  - The FAA has evaluated at least two vendor light dimming systems; However, as of this writing, the FAA has not drafted performance requirements, and it is unclear when/if they will do so.

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> Approval of an ADLS will be on a case-by-case basis and may be modified, adjusted, or denied based on proximity of the obstruction or group of obstructions to airports, low-altitude flight routes, military training areas, or other areas of frequent flight activity.

- Paragraph 10.2.3 FAA Lighting and Marking Advisory Circular

FAA Requirements Related to ADLS in AC70/7460-1M

- Horizontal coverage requirement: ADLS must be able to detect an aircraft 3 nautical miles from the potential turbine or turbines.
- Vertical coverage requirement: ADLS must be able to detect an aircraft from 200 feet above the ground to up to 1,000 feet above the highest part of the turbine or group of turbines.
- For systems that can continuously monitoring the aircraft when it is within this volume of airspace, the lights should remain on until the aircraft exists the airspace. If detection is lost, the lights are required to stay on for 30 minutes
- For systems that cannot continuously monitor, the lights should remain on seven minutes for a single structure or for multiple structures (i.e. a wind farm), the widest dimension of the group of structures + 6 x 90 seconds.
- In the event of ADLS failure, it should turn all on lights in the wind farm.
- Communication and operational status of ADLS must be checked at least one every 24 hours.

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Questions?

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Maintaining safety while minimizing visual impacts: Wind turbines and lighting

Introduction

The U.S. wind power industry understands concerns some communities raise about the visual impacts from wind turbine lighting, which the Federal Aviation Administration (FAA) requires in order to maintain aviation safety. Over the years, the wind industry has encouraged the FAA to take steps to reduce the visual impact of turbine lights on communities while still ensuring visibility for pilots. The FAA has been receptive to many of these suggestions, like generally not requiring every turbine in a wind farm to be lit; requiring simultaneous flashing; allowing aggregation of lighting plans with nearby wind farms to reduce overall lighting impacts; and evaluating technologies to reduce lighting effects. The wind industry remains committed to minimizing community concerns about lighting in ways that are consistent with FAA rules and ensure aviation safety.

Summary

Under federal law, the FAA has exclusive authority to regulate our nation's airspace.[1] Developers intending to construct or alter a structure that exceeds 200 feet (ft; 61 meters [m]) above ground level (AGL) must notify the FAA of their plans by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1). Depending on structure height and its proximity to aviation facilities, structures lower than 200 feet may also require FAA notification.[2]

Once the FAA is notified, an aeronautical study is conducted with input from as many as 10 federal offices and agencies. The FAA may also solicit feedback from the flying community through a public comment period. If no concerns are raised, or concerns can be mitigated without a significant effect on the National Airspace System, the FAA will issue favorable determinations at the end of its review. The FAA will describe the marking and lighting requirements in these determinations.

For all structures taller than 200 feet AGL, including wind turbines, the FAA requires marking and lighting to ensure they are visible to pilots during both daytime and nighttime conditions. The FAA notes other lighting should not be used in lieu of FAA-recommended marking and/or lighting, because FAA recommendations may vary depending on terrain features, weather patterns, geographic location, and the total number of wind turbines and overall design layout.

FAA Wind Turbine Lighting Standard

While the central focus is on aviation safety, the FAA's marking and lighting standards were also developed in coordination with the U.S. Fish and Wildlife Service to ensure low wildlife impacts.[3] FAA wind turbine recommendations include:

- Each wind turbine is painted white to ensure daytime visibility. Daytime lighting of wind turbines is not required.
- Nighttime obstruction lighting should consist of FAA L-864 aviation red flashing strobe, or pulsed obstruction lights. According to the FAA AC, studies have shown that red lights provide pilots with the highest visibility.
- For wind turbines with tip heights below 500 ft (152.4 m) AGL, obstruction lights can be omitted provided there are no unlit gaps greater than ½ statute mile (SM; 804 m) (Figure A-25 in Appendix A of the FAA Advisory Circular).

[1]Title 49 U.S.C Sec. 40103 provides "The United States Government has exclusive sovereignty of airspace of the United States." Courts have struck down as unconstitutional efforts where state or local governments attempt to regulate airspace issues in potential conflict with the FAA.

[2]14 CFR Part 77.7 and Part 77.9

[3] FAA Advisory Circular 70/7460-1M, last updated November 11, 2020. Chapter 13 is specific to lighting and marking of wind turbines.

- For all wind turbines at or greater than 500 ft (152.4 m) AGL, each wind turbine should be lit with two FAA L-864 red flashing lights on the nacelle, regardless of their location within a wind farm (Figure A-28 in Appendix A of the FAA Advisory Circular).
- All wind turbines at or greater than 699 ft (213 m) should be lit with an additional level of FAA L-810 lights located at a point on the tower midway between the top of the nacelle and ground level (Figure A-28 in Appendix A of the FAA Advisory Circular). These additional lights are required to flash in unison with the two L-864 red flashing lights located at the top of the nacelle.
- Regardless of turbine tip height, all lighting should be synchronized to flash simultaneously (e.g., within 0.05 second of each other) at a rate of 30 flashes per minute (fpm; +/- 3 fpm).

Light Mitigation Technology

Aviation detection lighting systems (ADLS) are radar-based systems that keep turbine lights off unless an aircraft is approaching or descending towards a wind farm. For these systems, the FAA requires the lighting be activated and flashing if an aircraft is at or below 1,000 feet above the tallest wind turbine and is approaching a three nautical mile (NM; 5.56 kilometers) perimeter around the project. Although the FAA's guidance has been published and a few ADLS vendors have been products certified as meeting FAA requirements, this does not mean ADLS can automatically be installed on a project. For each project that is considering using ADLS, a request must be made to the FAA, and the FAA evaluates each request on a turbine-by-turbine basis.[4] The FAA can deny the ADLS usage on certain turbines due to proximity to airports, low-altitude flight routes, military training areas, or other areas of frequent activity.[5] As a result, states and local communities should allow developers the flexibility to work through the feasibility of such systems on particular wind farms with the FAA.

Additionally, ADLS refers to a specific light mitigation technology solution. There are companies working on different technologies to mitigate the nighttime lighting impact, such as light dimming technologies. However, the FAA has not yet certified any light mitigation technology other than ADLS, nor have they provided guidance for how these systems would be implemented, if approved.

Conclusion

For wind turbines to comply with FAA determinations and to ensure the safety of the National Airspace System, marking and lighting must be installed in compliance with FAA's conditions and guidance. Therefore, to the extent local communities are also interested in establishing recommendations or requirements related to lighting, they need to be consistent with FAA requirements.

[4] Ibid. Chapter 10.

[5] Ibid. Section 10.2.3, Page 39. "Approval of an ADLS will be on a case-by-case basis and may be modified, adjusted, or denied based on proximity of the obstruction or group of obstructions to airports, low-altitude flight routes, military training areas, or other areas of frequent flight activity. It may be appropriate to keep certain obstructions closest to these known activity areas illuminated during the nighttime hours, while the remainder of the group's obstruction lighting is controlled by the ADLS."

CHAPTER 10. AIRCRAFT DETECTION LIGHTING SYSTEMS

10.1 Purpose.

Aircraft Detection Lighting Systems (ADLS) are sensor-based systems designed to detect aircraft as they approach an obstruction or group of obstructions; these automatically activate the appropriate obstruction lights until they are no longer needed by the aircraft. This technology reduces the impact of nighttime lighting on nearby communities and migratory birds and extends the life expectancy of the obstruction lights.

10.2 General Standards.

10.2.1. The system should be designed with sufficient sensors to provide complete detection coverage for aircraft that enter a three-dimensional volume of airspace, or coverage area, around the obstruction(s) (Figure A-20), as follows:

1. Horizontal detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the perimeter of the volume, which is a minimum of 3 NM (5.56 km) away from the obstruction or the perimeter of a group of obstructions. In some situations, such as when the 3 NM perimeter is not achievable, lighting uncontrolled by the ADLS may be required.

2. Vertical detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the volume, which extends from 200 feet above the ground up to 1,000 feet (304.80 m) above the highest part of the obstruction or group of obstructions, for all areas within the 3 NM (5.56 km) perimeter defined in subparagraph 10.2.1.1 above.

3. In some circumstances, it may not be possible to meet the volume area defined above because the terrain may mask the detection signal from acquiring an aircraft target within the 3 NM (5.56 km) perimeter. In these cases, the sponsor should identify these areas in their application to the FAA for further evaluation.

4. In some situations, lighting not controlled by the ADLS may be required when the 3 NM (5.56 km) perimeter is not achievable to ensure pilots have sufficient warning before approaching the obstructions.

10.2.2. The ADLS should activate the obstruction lighting system in sufficient time to allow the lights to illuminate and synchronize to flash simultaneously prior to an aircraft penetrating the volume defined above. The lights should remain on for a specific time period, as follows:

1. For ADLSs capable of continuously monitoring aircraft while they are within the 3 NM/1,000 foot (5.56 km/304.80 m) volume, the obstruction lights should stay on until the aircraft exits the volume. In the event detection of the aircraft is lost while being

continuously monitored within the 3 NM/1,000 foot (5.56 km/304.80 m) volume, the ADLS should initiate a 30-minute timer to keep the obstruction lights on until the timer expires. This should provide the untracked aircraft sufficient time to exit the area and give the ADLS time to reset.

2. For ADLSs without the capability of monitoring aircraft targets in the 3 NM/1,000 foot (5.56 km/304.80 m) volume, the obstruction lights should stay on for a preset amount of time, calculated as follows:

   a. For single obstacles: seven minutes.

   b. For groups of obstacles: (the widest dimension of the group in nautical miles + 6) x 90 seconds, equals the number of seconds the light(s) should remain on.

10.2.3. Approval of an ADLS will be on a case-by-case basis and may be modified, adjusted, or denied based on proximity of the obstruction or group of obstructions to airports, low-altitude flight routes, military training areas, or other areas of frequent flight activity. It may be appropriate to keep certain obstructions closest to these known activity areas illuminated during the nighttime hours, while the remainder of the group's obstruction lighting is controlled by the ADLS.

10.2.4. Project sponsors requesting the use of ADLS should indicate the location of the proposed sensors, range of each sensor, and a visual indication showing how each sensor's detection arc provides the full horizontal and vertical coverage, as required under paragraph 10.2.1 on their application maps or diagrams. In the event that detection coverage is not 100 percent due to terrain masking, project sponsors should provide multiple maps or diagrams that indicate coverage at the affected altitudes. A sample diagram is shown in Figure A-20.

10.2.5. Types of ADLS component or system failure events.

1. In the event of an ADLS component or system failure, the ADLS should automatically turn on all the obstruction lighting and operate in accordance with this AC as if it was not controlled by an ADLS. The obstruction lighting must remain in this state until the ADLS and its components are fully restored.
2. In the event that an ADLS component failure occurs and an individual obstruction light cannot be controlled by the ADLS, but the rest of the ADLS is functional, that particular obstruction light should automatically turn on and operate in accordance with this AC as if it was not controlled by an ADLS, and the remaining obstruction lights can continue to be controlled by the ADLS. The obstruction lighting will remain in this state until the ADLS and its components are restored.
3. Complete light failure should be addressed in accordance with Chapter 2, paragraph 2.4.

10.2.6. The ADLS's communication and operational status must be checked at least once every 24 hours to ensure both systems are operational.

10.2.7. The ADLS should be able to detect an aircraft with a cross-sectional area of one square meter or more within the volume, as required in subparagraphs 10.2.1.1. and 10.2.1.2.

10.2.8. Each ADLS installation should maintain a log of activity data for a period of no less than the previous 15 days. This data should include, but not be limited to, the date, time, duration of all system activations/deactivations, track of aircraft activity, maintenance issues, system errors, communication and operational issues, lighting outages/issues, etc.

10.2.9. Operational frequencies.

1. Unlicensed devices (including FCC Part 15) cannot be used for this type of system.

2. Any frequency used for the operation of ADLS must be individually licensed through the FCC.

CHAPTER 13. MARKING AND LIGHTING WIND TURBINES

13.1 Purpose.

This chapter provides guidelines for the marking and lighting applicable to single wind turbines and wind turbine farms. For the purpose of this AC, wind turbine farms are defined as a wind turbine development that contains more than three turbines. The recommended marking and lighting of these structures is intended to provide day and night conspicuity and to assist pilots in identifying and avoiding these obstacles.

13.2 General Standards.

The development of wind turbine farms is a very dynamic process, which changes based on the terrain. Each wind turbine farm is unique, therefore it is important that a lighting plan is developed that provides sufficient safety for air traffic. When developing lighting plans for wind turbine farms, it is best to use an aerial-view map or diagram of the turbine farm to plan the location of the required lighting. This way, a certain degree of strategy planning can be applied, which, in many instances, results in a minimal number of lights. Proximity to airports and VFR routes, extreme terrain where heights may vary widely, and local flight activity should be considered when developing a lighting plan. The following guidelines are recommended for wind turbines.

13.3 Wind Turbine Configurations.

Prior to marking and lighting the wind turbine farm, the configuration and the terrain of the wind turbine farm should be determined. The following is a description of the most common configurations (see Figure A-26):

1. Linear. Wind turbine farms in a direct, consecutive configuration, often located along a ridgeline, the face of a mountain, or along borders of a mesa or field. The line may be ragged in shape or be periodically broken, and may vary in size from just a few turbines to many turbines forming a line that is several miles long.

2. Cluster. Wind turbine farms arranged in circular configuration. A cluster is typically characterized by having a pronounced perimeter, with various turbines placed inside the circle at various, erratic distances throughout the center of the circle.

3. Grid. Wind turbine farms arranged in a geographical shape, such as a square or a rectangle, in which the turbines are placed a consistent distance from each other in rows, giving the appearance that they are part of a square pattern.

13.4 Marking Standards.

13.4.1 Wind turbines should be painted white or light grey, as these colors have been shown to be the most effective method for providing daytime conspicuity (see Figure A-26). Wind turbine manufacturers typically use a European color-matching system that is referred to as the RAL Color Standard. The RAL system uses a four-digit code to identify a specific color of paint, for example, an RAL 9xxx code would represent a color in the white/black range. The preferred white paint color is pure white, RAL 9010, or an equivalent, however most wind turbines currently produced are painted light grey, RAL 7035, which is the darkest acceptable off-white paint allowed. Any shade of white between these two RAL specifications is strongly recommended (see Table 13-1).

Table 13-1. Wind Turbine Paint Standard Colors

Color	RAL Number
Pure White (preferred color)	9010
Light Grey (Darkest Acceptable)	7035

13.4.2 In geographic areas that experience lengthy periods of snow cover (i.e., Alaska), and where it is deemed necessary, the mast of the turbine may be painted alternating bands of aviation orange and white to provide additional contrast against the snow. The nacelle and blades of the turbine must remain solid white or light grey (see Figure A-27).

13.4.3 Blades or blade tips must not be painted or manufactured in colors to camouflage wind turbines with the surrounding terrain.

13.4.4 For turbines that are constructed with lattice-type masts, the mast structure must be painted with alternating bands of aviation orange and white paint, in accordance with Chapter 3. The turbine's nacelle and blades must remain solid white or light grey.

13.5 Lighting Standards.

13.5.1 Studies have shown that red lights provide the most conspicuity to pilots, therefore during nighttime hours and periods of reduced visibilities, wind turbine obstruction lighting should consist of FAA L-864 aviation red flashing, strobe, or pulsed obstruction lights. Any array of flashing, strobe, or pulsed obstruction lighting should be synchronized to flash simultaneously (within ±1/20 second (0.05 second) of each other). Light fixtures should be placed as high as

possible on the turbine nacelle so they are visible by a pilot approaching from any direction (see Figure A-28). Should any lighting fixture or the lighting system synchronization fail, a lighting outage report should be prepared in accordance with Chapter 2, paragraph 2.4.

Daytime lighting of wind turbines is not required. See paragraph 14.4 for daytime marking requirements.

13.5.2 In most cases, not all wind turbine units within a wind turbine farm need to be lighted. Obstruction lights should be placed along the perimeter of the wind turbine farm so that there are no unlit separations or gaps more than 1/2 SM (0.80 km). Wind turbines within a grid or cluster should not have an unlighted separation or gap of more than 1 SM (1.61 km) across the interior of a grid or cluster of turbines (see Figure A-25).

1. Linear Turbine Configurations: Lights should be placed on the turbine positioned at each end of a line or string of turbines. Lights should also be placed along the line of turbines so that there is no more than a 1/2 SM (804.67 m) gap between the lighted turbines. In the event the gap between lights on the last segment of turbines is significantly short, it may be appropriate to move the lights on the turbine string back toward the starting point to present a well-balanced string of lights. High concentrations of lights should be avoided.

2. Cluster Turbine Configurations. A turbine should be selected as a starting point along the outer perimeter of the cluster. The turbine should be lighted, and a light should be placed on the next turbine along the perimeter of the cluster (clockwise or counterclockwise) so that no more than a 1/2 SM (804.67 m) gap exists. This pattern should be continued around the perimeter of the cluster until the starting point is reached. In the event that the gap between the lights on the last segment of turbines is significantly short, it may be appropriate to move the lights along the perimeter of the cluster back toward the starting point to present a well-balanced perimeter of lights. If the distance across the cluster is greater than 1 SM (1.61 km), additional lights should be placed on other turbines throughout the center of the cluster so that there are no unlighted gaps across the cluster. For example, if the distance across a wind turbine farm is 1.8 SM (2.90 km), a light should be placed on a turbine at approximately every 0.9 SM (1.45 km).

3. Grid Turbine Configurations. Turbines on the corners of the farm should be lit, and then use the same concept for selecting which turbines should be lit as outlined in paragraph 13.5.3.

13.5.3 Special Considerations.

Occasionally, some wind turbines may be located apart from the main group of turbines. If one or two wind turbines protrude from the general limits of the turbine farm, these turbines should be lighted in addition to those identified in the main group.Additional lighting may be necessary on wind turbines located on the interior of a cluster or grid configuration whose height is 100 feet (30.48 m) or higher than the other wind turbines located within the farm.

13.6 Wind Turbines Above 499 Feet (152.10 m).

13.6.1 For wind turbines with a rotor tip height, while at top dead center, greater than 499 feet (152.10 m) AGL, but less than 699 feet (213.06 m) AGL, the turbines should be lighted in accordance with paragraph 13.5. In addition to these requirements, the top of the turbine's nacelle should be equipped with a second L-864 flashing red light (see Figure A-28).

13.6.2 The two obstruction lights should be arranged horizontally, positioned on opposite sides of the nacelle, visible to a pilot approaching from any direction, and flash simultaneously. Using this lighting configuration ensures the conspicuity of turbines in this size category.

13.6.3 In the event one of the two obstruction lights fails, no light failure notification is required; however, the light should be restored to service as soon as possible.

13.6.4 All turbines within this size category should be illuminated, regardless of their location within a wind turbine farm, and should be configured to flash simultaneously with the other turbines in the same farm. This requirement ensures the pilots operating at low altitudes above 500 feet AGL have sufficient warning that a wind turbine obstruction may be within their flight path.

13.7 Wind Turbines at or Above 699 Feet (213.36 m).

13.7.1 For wind turbines with a rotor tip height, while at top dead center, at or above 699 feet (213.06 m) AGL, additional lighting is required. All wind turbines of this size, regardless of number or configuration should be lighted.

13.7.2 In addition to the lighting identified in paragraphs 13.5 and 13.6, an additional level of lights is required at a point midway between the top of the nacelle and ground level. The location of the additional lights may be adjusted as necessary to allow mounting at a seam within the turbine's mast.

13.7.3 The additional level of lights should consist of a minimum of three L-810 F flashing red lights configured to flash in unison with the two L-864 red flashing lights located at the top of the nacelle at a rate of 30 fpm (± 3 fpm). The L-810 F lights should be spaced at equal distances around the mast to ensure a pilot approaching from any direction has an unobstructed view of at least two of the lights (see Figure A-28).

13.7.4 For wind turbine structures with a mast diameter greater than 20 feet (6.10 m), four L- 810 red lights should be used.

13.7.5 All turbines within this size category should be illuminated, regardless of their location within a turbine farm, and should be configured to flash simultaneously with the other turbines in the same farm. This requirement ensures the pilots operating at low altitudes above 500 feet AGL have sufficient warning that a wind turbine obstruction may be within their flight path.

13.8 Lighting of Wind Turbines During Construction Phase.

To ensure proper conspicuity of turbines at night during construction, all turbines should be lighted with temporary lighting once they reach a height of 200 feet (60.96 m) or greater until the permanent lighting configuration is turned on. If practical, permanent obstruction lights should be installed and operated at each level as construction progresses. As the structure's height continues to increase, the temporary lighting should be relocated to the structure's uppermost height (see Figure A-30). An L-810 steady-burning red light must be used to light the structure during the construction phase, if the permanent L-864 flashing-red lights are not in place. The temporary lighting may be turned off for short periods if they interfere with construction personnel. If power is not available, turbines should be lighted with a self-contained, solar-powered, LED, steady-burning red light that meets the photometric requirements of an FAA L-810 lighting system. The lights should be positioned to ensure a pilot has an unobstructed view of at least one light at each level. Using a NOTAM to justify not lighting the turbines until the entire project is completed is prohibited.

13.9 Lighting and Marking of Airborne Wind Turbines.

The FAA is currently conducting research to develop special lighting and marking standards for Airborne Wind Turbines. Sponsors should consult with their respective FAA OE Specialists for updated information.

13.10 Lighting and Marking of Offshore Wind Turbines.

FAA lighting and marking recommendations for Offshore Wind Turbines applies to structures in United States territorial seas, which extends from the coastline to 12 NM offshore. The Bureau of Ocean Energy Management (BOEM), which maintains jurisdiction of land leases beyond the 12 NM, is developing their own marking and lighting standards for offshore wind turbines and new construction must comply with those standards.

CHAPTER 14. MARKING AND LIGHTING TEMPORARY STRUCTURES

14.1 Purpose.

This chapter provides general guidelines for marking and lighting temporary structures, such as construction equipment, cranes, derricks, oil and drilling rigs, etc. The purpose of marking and lighting these obstructions is to indicate the presence and general outline of the structure to assist pilots when approaching from any direction to identify and avoid these obstacles. These guidelines are not to be considered all-inclusive, each obstacle must be evaluated individually and the determination will provide lighting requirements that are specific to the structure.

14.2 General Standards.

Due to the temporary nature, potential mobility, and ability to instantaneously extend to full height, accommodations must be made to mitigate the effects of these structures on the airspace for safe operations. Temporary structures are unique based on the structure type, size, and use, and the aeronautical study evaluates the potential effect on airspace. Proximity to airports, navigational aids (NAVAIDS), air routes, and local flight activity, as well as the duration of the project are considered during the evaluation process.

Marking and/or lighting of these structures is intended to provide day and night conspicuity and to assist pilots in identifying and avoiding these obstacles. In some cases, the Sponsor will also be required to initiate a NOTAM to provide additional mitigation procedures for the safe operation of the temporary obstacle due to the proximity of these aviation elements.

14.3 Marking Standards.

Marking is used to increase conspicuity of structures for daytime conditions. Flags are used to mark certain structures or objects when it is technically impractical to use paint. When using paint, various types of paint colors and patterns are used to mark structures and the pattern should ensure the paint contrasts with the surrounding environment.

14.3.1 Flag Markers.

Flag markers must be mounted at the highest point of the structure to ensure visibility. Some common examples of structures that may utilize this type of markers include, temporary construction equipment and vehicles, oil and drilling rigs, cranes, and derricks. Refer to Section 3.5.2 for full details.

1. Minimum Size. Each side of the flag marker should be at least two feet (0.61 m) in length.

2. Color Patterns. Flags should be colored as follows:

   a. Solid colored flag must be aviation orange.