



Appendix I

Light Impact Assessment

Light Impact Assessment


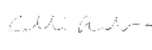
Argentia Renewables Project

Pattern Energy

9 April 2024

→ The Power of Commitment



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GHD

Contact: Matthew Griffin, Engineering Leader | GHD

455 Phillip Street, Unit 100A

Waterloo, Ontario N2L 3X2, Canada

T +1 519 884 0510 | F +1 519 884 0525 | E info.northamerica@ghd.com | ghd.com

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1. Introduction

GHD Limited (GHD) has undertaken an analysis of the proposed lighting installations for the onshore wind generation and green hydrogen and ammonia production, storage and export facility project, as part of the Argentia Renewables Project (Project) being developed on the Argentia Peninsula of Placentia Bay in Newfoundland and Labrador (NL). The site (Site) consists of the hydrogen and ammonia plant, which will be located on the brownfield peninsula formerly used for military purposes, and the wind turbine generators (WTG), which will be located on adjacent Port of Argentia private lands locally referred to as the "Argentia Backlands". The "Argentia Backlands" are north of the communities of Dunville, Ferndale and Freshwater. The Site is in a rural area that has portions that are wooded as well as nearby the water. The impacts of the proposed activities at the Site on nearby sensitive receptors were quantified and compared with the guidelines published by The Institution of Lighting Engineers (ILE) in the document entitled "Guidance Notes for the Reduction of Obtrusive Light". There are currently no regulations in Newfoundland and Labrador related to light from industrial operations.

Definitions

Light trespass is defined as the spilling of light beyond the boundary of the property or area being lit and is primarily a concern at night. Excess obtrusive light can be a nuisance to others, wastes electricity, and indirectly results in unnecessary emissions of greenhouse gases. Light trespass, or light pollution, can also negatively impact the surrounding ecosystem by disrupting the habits of native species. As such, it is important to understand the potential light impacts from this development, and to endeavor to minimize them.

Luminous flux is the quantity of the energy of the light emitted per second in all directions. The unit of luminous flux is lumen (lm).

Illuminance refers to the amount of light that covers a surface. If Φ is the luminous flux and S is the area of the given surface then the illuminance E is determined by $E = \Phi/S$. Illumination is quantified in terms of lux. One lux is the illuminance of a 1 square metres (m^2) surface uniformly lit by 1 lm of luminous flux.

A residence that may experience an objectionable encroachment of light over the property line is referred to as a *residential receptor* or *sensitive receptor*. This undesirable light spill may include the entry of unwanted light through windows, or direct line of sight to bright light sources.

Effects of light on fauna are not well understood and are generally described qualitatively. Some insects are attracted by nighttime lighting. Bats may follow these insects into human-occupied areas in order to hunt. Nighttime lights can adversely affect birds which fly at night, and can increase the incidence of bird impacts on buildings (especially highly reflective buildings or glass buildings where interior lighting may confuse birds). Nocturnal animals may be adversely affected by excessive light in the nighttime hours.

Nocturnal animals which may be affected by nighttime light, changing their movement patterns or activities, include owls, mink, badgers, bats, coyotes, wolves, mice, opossums, raccoons, foxes, skunks, mountain lions (cougar). Deer and moose prefer dawn and dusk hours, both of which may be affected by Project lighting, but the effects of Project lighting are likely to be less significant to hunting practices than general human activity.

Deer and moose prefer to avoid people, if possible, and may modify their behavior/distribution due to the presence of the Site activities, regardless of lighting.

1.1 Purpose of this Report

The purpose of this report is to present the method of assessment, results, and best management practices of the light impact assessment for the Argentia Renewables Project.

1.2 Scope and Limitations

This report: has been prepared by GHD for Pattern Energy and may only be used and relied on by Pattern Energy for the purpose agreed between GHD and Pattern Energy as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Pattern Energy arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

2. Baseline Conditions

The ILE has developed an Environmental Zone classification system whereby the existing ambient light levels at a site are used to determine the recommended maximum amount of light trespass to nearby receptors. The classification for rural areas, small villages, or relatively dark urban locations is "E2 Low district brightness areas". Based upon this classification, the light trespass limit at an off-site receptor after curfew (typically considered to be 11 p.m.) is 1 lux, which is the accepted equivalent to moonlight.

Furthermore, the ILE trespass limit at an off-site receptor before curfew is 5 lux.

Project lighting will be limited to the amount necessary to ensure safe and efficient operation, with the recognition that excessive lighting can be disruptive to wild species, local residents and businesses. Light pollution will be reduced by installing downward-facing lights on buildings, WTG bases and access roads. Wherever possible, ground-level external lights on buildings and WTG bases will be pointed downward and shall use motion or heat sensors when possible and permitted by relevant codes and the authority with jurisdiction. Only direct and focused light will be used for worker safety. WTG and meteorological tower lighting levels will be at a minimum allowed by Transport Canada for aeronautical safety, and white or red strobe lights may be used with the minimum intensity and flashes per minute allowable.

Bird collisions with Project lighting and subsequent mortality are expected to be rare but if it occurs, it would not likely have significant effects on migrating bird populations. Efforts will be made to reduce the effect of lighting on migrating birds. No monitoring is being proposed.

3. Proposed Lighting

The Project involves the lighting at the hydrogen and ammonia plant and the wind turbines. Both locations have been evaluated to determine the impact on the area.

Since the exact locations of the equipment/lights are unknown, the closest location compared to the receptor was used for the purposes of the calculations. As it is unknown the specific equipment type that is going to be used throughout the program it was estimated that standard equipment would be used.

Navigation light fixtures will be installed on some wind turbines as per the requirements of Transport Canada Standard 621 - Obstruction Marking and Lighting (*Canadian Aviation Regulations*). The number of lights will be determined by Transport Canada based on the final layout and design.

4. Sensitive Receptors

For the purposes of the evaluation, the closest sensitive receptor to the turbines and the plant were selected for the evaluation. The nearest residential receptors were identified in each direction around the property and work areas.

Figure 1 provides the locations of all these receptors and the locations of the proposed Site activities.

5. Method of Assessment

GHD completed the assessment based on the equipment list that was expected based on similar projects. From known information about the power output of the installations and typical efficiencies, the luminous flux of each light source was calculated:

$$\text{Luminous Flux (lm)} = \text{Power Output (watts)} \times \text{Efficiency} \left(\frac{\text{lumens}}{\text{watt}} \right)$$

The power output of the proposed lighting was known from manufacturer information, and the efficiency was based on typical industry published values, as presented in the following table.

Type of Light	Typical Efficiency (lumens/watt)
LED	58 – 113
Compact Fluorescent	70
Linear Fluorescent	108
Incandescent	15
Halogen	20
High Pressure Sodium	100

Sample Calculation:

The expected equipment at the Hydrogen/Ammonia Facility and Wind Turbine are provided in Table 1. The number and type of lights and their power output are also provided in Table 1. The luminous flux of the Crane can be calculated as follows:

$$\text{Power Output} = 1 \text{ crane} \times 6 \frac{\text{Lights}}{\text{crane}} \times 65 \frac{\text{W}}{\text{Light}} = 390 \text{ W}$$

$$\text{Luminous Flux} = 390 \text{ W} \times 20 \frac{\text{lumens}}{\text{W}} = 7,800 \text{ lumens}$$

After determining luminous flux estimates for each light source, the impacts of the incident light at the identified sensitive receptors can be determined.

Table 1 indicates the estimated distance to the sensitive receptors from these sources. The illuminance level at a receptor is equal to the combined total from each light source. It has been conservatively assumed that 50 percent of

the incident light will not reach the receptor due to the thick tree cover at the Site and surrounding area. The following equation was used to estimate the illuminance contribution from each light source:

$$E = \frac{\phi}{d^2} \times 50\%$$

Where:

- E = illuminance (lux)
- ϕ = luminous flux (lm)
- d = distance to the receptor (m)

Sample Calculation:

The luminous flux from the equipment that will be used at the Hydrogen/Ammonia facility is estimated at 381,000 lm. The distance to the closest receptor from Argentia Green Fuels Facility is approximately 4042 m. The illuminance contribution from the Facility to the closest receptor can be estimated as follows:

$$\text{Illuminance} = \frac{381,000 \text{ lumens}}{(4,042 \text{ m})^2} \times 50\% = 1.17 \times 10^{-2} \text{ lu}$$

This method was used to determine the estimated illuminance at the closest receptor from the wind turbines as well.

The table summarizing the Facility and the turbine is provided in Table 1. This table identifies all expected sources at each location. Table 2 provides a comparison of the illuminance and the pre-curfew limit of 5 lux. Table 3 provides the comparison of the post curfew activities to the post-curfew criteria of 1 lux.

For the purposes of this assessment, pre-curfew was assumed to be before 11 PM and post-curfew was between 11 PM and 7 AM.

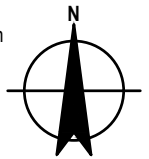
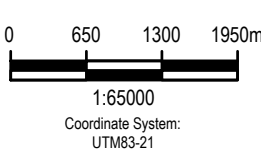
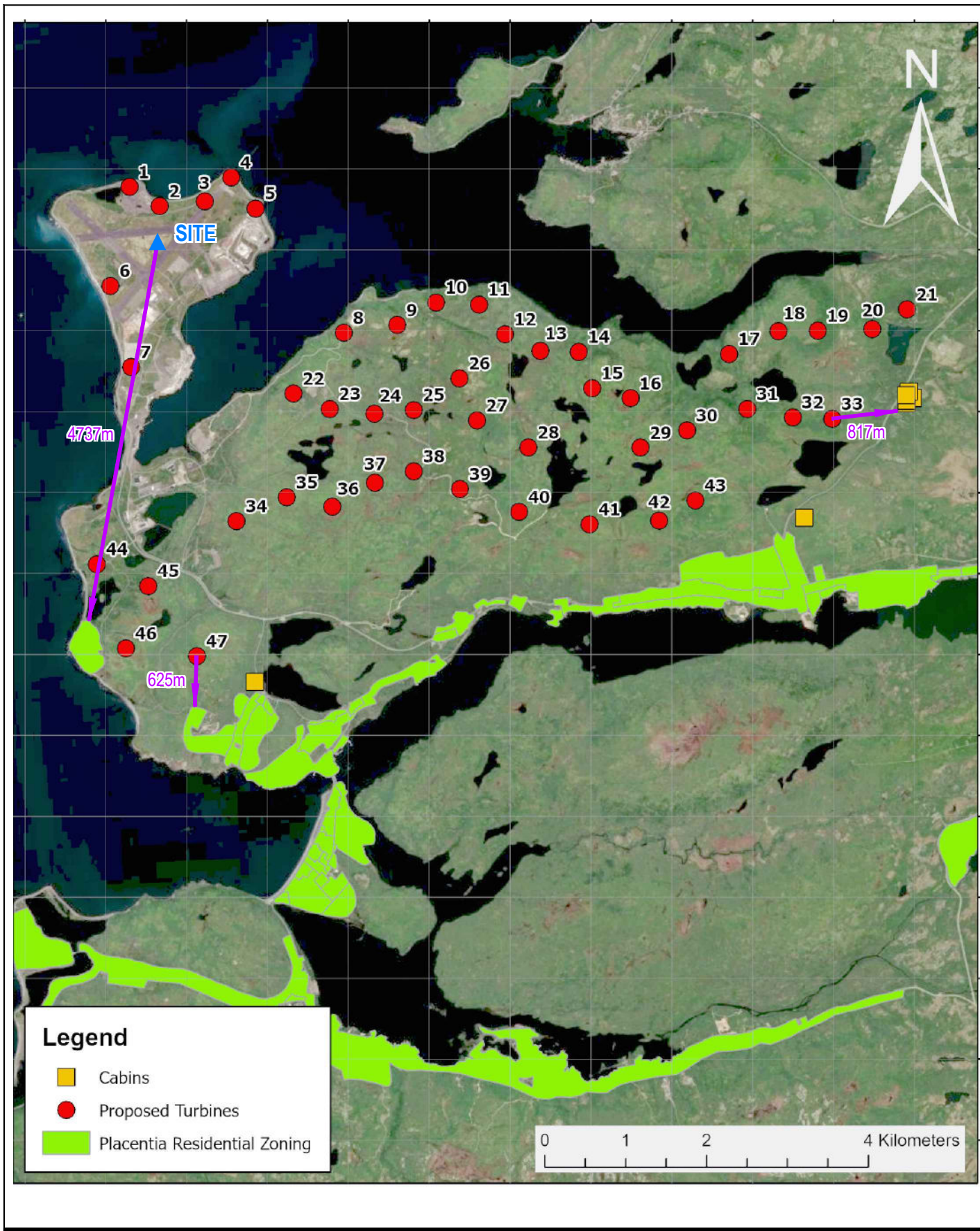
6. Results and Discussion

The calculated light levels at the identified sensitive receptors are below the limits recommended by the ILE guidelines during both post- and pre-curfew conditions, as shown in Tables 2 and 3, respectively.

The predicted illuminance levels represent the worst-case operating conditions of the Project. The assessment considers when all of the equipment is operating at the same time and at the closest location to the receptor. The areas surrounding the Site are wooded with varying topography and inhibit the spread of light. It was conservatively assumed for screening purposes that 50 percent of the light will not reach the receptors due to directionality and line of sight obstructions. In reality the amount of light blocked by the surrounding woodland and topographic changes will likely be much greater than this (>90 percent), especially during the seasons when trees are in full bloom.

7. Best Management Practices

Routine monitoring of the light levels at the Site, once constructed and operational, using a light meter will provide an opportunity to compare actual light levels with theoretical. More refined light level measurements could assist in further quantifying the effects of light sources on the sensitive receptors.



PATTERN ENERGY
ARGENTIA RENEWABLES PROJECT

**SITE AND POINT OF RECEPTION
LOCATION PLAN**

Project No. 12618385
Date March 2024

FIGURE 1

Table 1
Light Source Summary Tables
Pattern Energy
Argentia Renewables Project

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source (2)			Power (watts)	Qty	Total Power (watts)	Luminous Flux (1) (lumens)	Closest Receptor		
								Approx. Distance (m)	Illuminance (1) (lux)	
Hydrogen/Ammonia Facility	Quantity of Units	No. Of Lights per Unit	Type of Light							
	Truck	1	4	Halogen	65	4	260	5200	4737	1.16E-04
	Backhoe	2	6	Halogen	65	12	780	15600	4737	3.48E-04
	Crane	1	6	Halogen	65	6	390	7800	4737	1.74E-04
	Dump Truck	3	4	Halogen	65	12	780	15600	4737	3.48E-04
	Dozer	3	6	Halogen	65	18	1170	23400	4737	5.21E-04
	Excavator	3	6	Halogen	65	18	1170	23400	4737	5.21E-04
	Grader	2	6	Halogen	65	12	780	15600	4737	3.48E-04
	Haul Truck	2	4	Halogen	65	8	520	10400	4737	2.32E-04
	Loader	3	6	Halogen	65	18	1170	23400	4737	5.21E-04
	Roller	2	6	Halogen	65	12	780	15600	4737	3.48E-04
	Articulated Truck	1	6	Halogen	65	6	390	7800	4737	1.74E-04
	Skid Steer	2	6	Halogen	65	12	780	15600	4737	3.48E-04
	Lube Truck	2	4	Halogen	65	8	520	10400	4737	2.32E-04
	Service Truck	2	4	Halogen	65	8	520	10400	4737	2.32E-04
	Water Truck	3	4	Halogen	65	12	780	15600	4737	3.48E-04
	Vacuum Truck	1	4	Halogen	65	4	260	5200	4737	1.16E-04
	Turbine Lights (4)	1	4	LED	85	4	340	6800	625	8.70E-03
	Turbine Lights (4)	1	4	LED	85	4	340	6800	817	5.09E-03
	Flare	1	1	Flare	-	-	-	85000 (3)	4737	1.89E-03
Mobile Floodlights	10	1	Floodlight	350	10	3500	70000	4737	1.56E-03	
Polemount Lights	60	1	LED	75	60	4500	90000	4737	2.01E-03	

POST-CURFEW	Total:	2.42E-02
PRE-CURFEW	Total:	2.42E-02

Area	Source (2)			Power (watts)	Qty	Total Power (watts)	Luminous Flux (1) (lumens)	Closest Receptor		
								Approx. Distance (m)	Illuminance (1) (lux)	
Wind Turbines	Lube Truck	1	4	Halogen	65	4	260	5200	625	6.66E-03
	Service Truck	1	4	Halogen	65	4	260	5200	625	6.66E-03
	Haul Truck	1	4	Halogen	65	4	260	5200	625	6.66E-03
	Grader	1	6	Halogen	65	6	390	7800	625	9.98E-03
	Turbine Lights (4)	1	4	LED	85	4	340	6800	625	8.70E-03
	Turbine Lights (4)	1	4	LED	85	4	340	6800	817	5.09E-03
	Excavator	1	6	Halogen	65	6	390	7800	625	9.98E-03

POST-CURFEW	Total:	5.37E-02
PRE-CURFEW	Total:	5.37E-02

Notes:

- (1) Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m². United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>
- (2) Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.
- (3) Estimate
- (4) The two closest turbines have been included in the evaluation. Based on the evaluation the turbines located at greater distances would have a negligible impact on the overall results and have not been included.

Table 2

**Comparison of Light Levels at Receptors - Pre-Curfew Operations
Pattern Energy
Argentina Renewables Project**

Receptor	Facility Illuminance (lux) Pre-Curfew (2)	Wind Turbine Illuminance (lux) Pre-Curfew (2)	ILE Guidance Limit (1) Pre-Curfew (2) (lux)	Percentage of Criteria (3) Pre-Curfew (%)
Closest Receptor	2.42E-02	5.37E-02	5	1.07%

Notes:

(1) Based on a classification of the area as Environmental Zone E2- Low district brightness areas (Guidance Notes for the Reduction of Obtrusive Light, The Institute of Lighting Engineers (2011)).

(2) Curfew = the time after which stricter requirements for the control of obtrusive light will apply. If not defined by the local planning authority, the ILE suggests 11:00 p.m. The Institute of Lighting Engineers (2011). Obtrusive Light, "Table 1-Obtrusive Light Limitations for Exterior Lighting Installations",)

(3) Based on conservative assumption of 50% reduced light due to directionality and line of site obstructions.

Table 3

**Comparison of Light Levels at Receptors - Post-Curfew Operations
Pattern Energy
Argentia Renewables Project**

Receptor	Facility Illuminance (lux) Post -Curfew (2)	Wind Turbine Illuminance (lux) Post -Curfew (2)	ILE Guidance Limit (1) Post-Curfew (2) (lux)	Percentage of Criteria (3) Post-Curfew (%)
Closest Receptor	2.42E-02	5.37E-02	1	5.37%

Notes:

(1) Based on a classification of the area as Environmental Zone E2- Low district brightness areas (Guidance Notes for the Reduction of Obtrusive Light, The Institute of Lighting Engineers (2011)).

(2) Curfew = the time after which stricter requirements for the control of obtrusive light will apply. If not defined by the local planning authority, the ILE suggests 11:00 p.m. The Institute of Lighting Engineers (2011). Obtrusive Light, "Table 1-Obtrusive Light Limitations for Exterior Lighting Installations")

(3) Based on conservative assumption of 50% reduced light due to directionality and line of site obstructions.

