15 OTHER IMPACTS

15.1 AIR QUALITY

15.1.1 *Impact Description and Assessment*

This section considers the impacts to air quality during the construction and operation of the Roggeveld Wind Farm. Potential impacts likely to arise during the construction and the operational phases of the development are summarised in *Table 155.1*, below. It should be noted that development of wind-powered electrical generation, such as the proposed Roggeveld Wind Farm would result in an improvement to air quality by offsetting emissions created by fossil-fuel-burning power plants. However, during construction there may be short-term localized air quality impacts. Temporary, minor adverse impacts to air quality may result from the operation of construction equipment and vehicles. Impacts to ambient air quality are likely to arise from the following:

- dust generated during clearing of vegetation and by the preparation of site surfaces by earthworks;
- dust generated from vehicles on site travelling along unpaved access roads; and
- exhaust emissions from vehicles during construction.

Table 155.1 Impact Characteristics: Air Quality

Summary	**Construction**	**Operation**
Project Aspect/ activity	Vehicle movement on gravel / dirt roads. Soil disturbance and excavating. Emissions from construction vehicles and equipment.	Vehicle movement on gravel roads.
Impact Type	Direct negative	Direct negative
Stakeholders/ Receptors Affected	• Affected landowners • Road users • Construction personnel	• Affected landowners

Construction Phase Impacts

Dust-producing activities are likely to be more common during the early phases of construction, and mainly include site leveling (including blasting), the handling of spoil from leveling and clearing activities and vehicle movements. It is likely that dust generation would result from vehicles travelling along the secondary roads and the site's internal road network.

The increased dust and emissions would likely not be sufficient to significantly impact local air quality. However, increased dust can be a nuisance to site users, landowners and nearby receptors. Airborne dust could potentially be deposited on neighboring properties and vegetation in and around the site. In extreme cases, dust can cause respiratory problems for site users through inhalation, although this is not likely to occur at this site since construction activities will be progressive.

Dust becomes airborne due to the action of winds on material stockpiles and other dusty surfaces, or when thrown up by mechanical action, for example the movement of tyres on a dusty road or activities such as excavating. The levels of dust are expected to be highly variable and dependent on the time of year, the intensity of the activity and the prevailing winds at the time of construction. The quantity of dust released during construction depends on a number of factors, primarily:

- the type of construction activities occurring (e.g. crushing and grinding);
- volume of material being moved;
- the area of exposed materials;
- the moisture and silt content of the materials;
- distances travelled on unpaved surfaces; and
- the mitigation measures employed.

Dust emissions are exacerbated by dry weather and high wind speeds. During summer months, the area can be relatively dry and consequently, dust levels are high from the surrounding area and unpaved track roads. The impact intensity of dust also depends on the wind direction and the relative locations of dust sources and receptors.

There is potential for dust emissions during construction to impact on residential receptors or sensitive habitats, if these are within 200 m of an activity causing dust production. Potential receptors on and around the site include:

- neighbouring properties and agricultural lands;
- secondary public road users; and
- internal road network users.

The activities resulting in increased dust levels would be limited to the early stages of the construction phase (preparation of construction surfaces), and would be limited in time and space (in the order of one to several months in one given location).

Box 155.1 Construction Impact: Roggeveld Wind Farm – Dust

Nature: Site levelling, vehicle movement on farm and public roads and other construction activities that generate dust would result in a **negative direct** impact on receptors in the area.

Impact Magnitude – Low

- **Extent**: The extent of the impact is **local,** limited to within 200 m of construction activities, potentially impacting neighbouring farms.
- **Duration**: The duration would be **short-term** for the 24 months duration of site preparation and construction.
- **Intensity:** Increased dust is unlikely to impact any sensitive receptors, due to the position of the receptors in relation to construction activities, therefore the intensity can be considered **low.**

Likelihood – There is a **definite** likelihood of dust generation from clearance of vegetation, earthworks and from vehicles travelling on the roads within and outside the site.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **high**.

Site preparation and construction work requires the use of a range of equipment, such as excavators, piling equipment and cranes to erect turbines as well as on-site generators and hand tools. Many of these lead to a direct emission of exhaust gas. Such emissions would enter the atmosphere and are likely to disperse quickly depending on weather and wind speeds. The level of emissions generated is not predicted to be high. However, these emissions have the potential to impact people living in the area. Degradation of air quality from the increase in emissions is not anticipated, given the short nature of the site preparation and construction works (i.e. intermittently for 24 months) and the nature of the proposed activities. Therefore, impacts to local residents are not expected and the impact is considered to be **negligible**.

Operational Phase Impacts

Minimal dust and emission generation is expected to occur during the operational phase of the project by maintenance vehicles along the gravel access roads, which would be infrequent. Therefore, impact of dust and emissions generated during the operation phase is not considered any further.

15.1.2 Mitigation Measures

Inherent to the management of construction activities and according to construction best practice, typical dust mitigation measures should be in place and are listed below. It should be noted, however that as the site is located in a water-scarce area, wetting of surfaces to minimise dust is not recommended during any phase of the development.

Construction phase

- Vehicles travelling on unpaved or gravel roads must not exceed a speed of 40 km/hr;

- Stockpiles of dusty materials must be enclosed or covered by suitable shade cloth or netting to prevent escape of dust during loading and transfer from site;

- Vehicles are to be kept in good working order and serviced regularly to minimise emissions; and

- All directly affected and neighbouring farmers and local residents must be able to lodge grievances with G7 using the Grievance Procedure (included in the EMP) regarding dust emissions that could be linked to the project.

Operation phase

- Vehicles travelling on unpaved or gravel roads must not exceed a speed of 40 km/hr.

15.1.3 Residual Impacts

Impacts from dust and emissions are anticipated to be negligible during the operational phase. Impacts related to an increase in dust during the site preparation and construction phase would be minor should suggested mitigation be implemented.

Table 155.2 Pre- and Post- Mitigation Significance: Roggeveld Wind Farm – Dust and Emissions

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction (dust)	**MINOR (-VE)**	**MINOR (-VE)**
Construction (emissions)	**NEGLIGIBLE (-VE)**	**NEGLIGIBLE (-VE)**
Operation (dust & emissions)	**NEGLIGIBLE (-VE)**	**NEGLIGIBLE (-VE)**

15.2 TRAFFIC IMPACT

15.2.1 Impact Description and Assessment

Potential impacts to traffic and road users likely to arise during the construction and the operational phases of the Roggeveld Wind Farm are summarised in *Table 155.3*, below.

Table 155.3 Impact Characteristics: Traffic

Summary	Construction	Operation
Project Aspect/ activity	Delivery of turbine components and construction equipment. Delivery of concrete. Construction personnel commuting to and from site.	Operational personnel commuting to and from site. Delivery of replacement turbine components.
Impact Type	Direct negative	Direct negative
Stakeholders/ Receptors Affected	• Road users • Affected landowners	• Road users • Affected landowners

Construction Phase Impacts

During the construction phase of the Roggeveld Wind Farm, there would be an increase in vehicle movement to and from the site. This has the potential to impact on traffic along the transport route and within the site boundaries. It is assumed that wind turbine components and other equipment would be brought in by road freight, from the Port of Cape Town, the Port of Saldanha or whichever port might be finally found suitable in respects of capacity, location and accessibility at the time of construction. The site is accessed via the N1 National road and the R354. A transport study would be undertaken approximately one year prior to the commencement of construction, in order to determine the most appropriate route to transport the equipment from the selected port to site.

The turbines and other construction materials would be delivered to site on low-bed trucks. The trucks delivering turbine components would be considered to be carrying abnormal loads in terms of the Road Traffic Act (Act No 29 of 1989). Approximately eight truck loads would be required per turbine:

- One for the nacelle;
- Three for the turbine tower;
- One for the spinner and hub; and
- Three for the blades.

Up to 2000 vehicles would be required to deliver the wind turbine components for the 250 proposed turbines. Other heavy vehicle deliveries would be required to transport cables, machinery and construction material for the proposed hard standing area and substation.

An on-site batching plant is likely to be developed (subject to the appropriate permits) to mix concrete onsite. In addition, G7 will require aggregate material that is likely to be sourced from opening one or more new borrow pits on site. The presence of an on-site batching plant and borrow pit would minimize the number of vehicle movements required to and from the site. In the event that a batching plant is not developed, each foundation would take between 80 and 90 loads of concrete (assuming each load is approximately 6 m^3), resulting in approximately eight deliveries per hour for a day for each turbine foundation.

It is estimated that approximately 358 local construction jobs would be created for the duration of the construction phase and these workers would travel to and from the site daily during the construction period. The construction phase of the project would take approximately 24 months per 200 MW and during this time increases in traffic levels would be intermittent and temporary in nature.

The increase in traffic, especially from heavy loads, could create noise, dust and safety impacts for other road users and people living or working within close proximity to the roads selected as transport routes. In addition, the increased volume of traffic along the final transport route would increase the wear and tear on these roads and possibly lead to deterioration in road conditions.

Box 155.2 Construction Impact: Roggeveld Wind Farm – Traffic

Nature: Vehicles required for the transport of infrastructure (e.g. turbines and cables) and materials would result in a **negative direct** impact on the roads used and road users.

Impact Magnitude – Medium

- **Extent**: The extent of the impact is **regional** as the potential impact will extend along the selected transport route.
- **Duration**: The duration would be **short-term** for the duration of construction, up to 24 months.
- **Intensity:** The intensity is likely to be **medium** given that the increase in traffic would be temporary, but may create a nuisance and impact on the safety of other road users.

Likelihood – There is a **definite** likelihood of increased traffic.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE (-VE)

Degree of Confidence: The degree of confidence is **medium** as the exact number of vehicles visiting the site is not known.

Operation Phase Impacts

There would be a dedicated operations team comprising 122 full time personnel operating the facility. These employees would have to commute to and from the site on a daily basis. Maintenance staff would visit the site several times a month requiring one or two vehicles. In addition, infrequent deliveries of replacement parts may be made during the lifespan of the Wind Farm. Potential traffic impacts associated with the operation of the facility would be largely limited to the site and the local access road, therefore having the potential to impact the farm owners and users of the access roads to the site and the road network on the site.

Box 155.3 Operation Impact: Roggeveld Wind Farm – Traffic

Nature: Increased traffic from workers travelling to and from the site would result in a **negative direct** impact on people who use the access roads to the site, and the road network used on the site.

Impact Magnitude – Low

- **Extent**: The extent of the impact is **local** as impact would be restricted to the immediate vicinity of the site.
- **Duration**: The duration would be **long-term** for the operation of the Wind Farm, up to 25 years.
- **Intensity:** The intensity is likely to be **low** given that the increase in traffic would be minimal.

Likelihood – There is a **definite** likelihood of increased traffic in the area surrounding the site and onsite.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **high.**

15.2.2 Mitigation Measures

Design

- A transport study will be undertaken approximately one year prior to the commencement of construction to determine the most appropriate route from port to site. All necessary transportation permits will be applied for at this stage;

- G7 will develop a Traffic Management Plan including strict controls over driver training, vehicle maintenance, speed restrictions, appropriate road safety signage, and vehicle loading and maintenance measures; and

- G7 to develop a policy and procedure for assessing all damages and losses (e.g. damage to property, injury or death of people or livestock) resulting from project vehicles.

Construction

- During construction, arrangements and routes for abnormal loads must be agreed in advanced with the relevant authorities and the appropriate permit must be obtained for the use of public roads; and

- All directly affected and neighbouring farmers and local residents must be able to lodge grievances with G7 using the Grievance Procedure (see the EMP in *Annex L*) regarding dangerous driving or other traffic violations that could be linked to the project.

Operation

- During operation, if abnormal loads are required for maintenance, the appropriate arrangements must be made to obtain the necessary transportation permits and the route agreed with the relevant authorities to minimise the impact on other road users.

15.2.3 *Residual Impacts*

Impacts from an increase in traffic during the construction and operational phase would be reduced to minor and negligible respectively should the proposed mitigation measures be implemented.

Table 155.4 Pre- and Post- Mitigation Significance: Roggeveld Wind Farm - Traffic

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	**MODERATE-MAJOR (-VE)**	**MINOR (-VE)**
Operation	**MINOR (-VE)**	**NEGLIGIBLE**

15.3 WASTE AND EFFLUENT

This section focuses on the potential impacts associated with waste and effluent generated during the construction and operational phases of the Roggeveld Wind Farm development.

15.3.1 *Impact Description and Assessment*

The project would lead to the generation of several wastes streams. *Table 155.5* identifies the origin of waste and effluent associated with the construction and operational phases of the Roggeveld Wind Farm and the stakeholders or receptors likely to be affected.

Table 155.5 Impact Characteristics: Waste and Effluent

Summary	Construction	Operation
Project Aspect/ activity	Waste and/or effluent originating from: construction activities including excavation, unpacking of turbine equipment, general eating facilities on site and general office facilities.	Waste and/or effluent originating from: maintenance activities and general office facilities.
Impact Type	Direct negative	Direct negative
Stakeholders/ Receptors Affected	• Affect land owner • Surrounding habitat	• Affect land owner • Surrounding habitat

Construction Phase Impacts

Inevitably, the construction of the Wind Farm would result in the production of a variety of waste streams being generated. During site clearance and levelling, solid waste would be generated from vegetation clearance and soil overburden. Construction rubble would be produced throughout the construction phase from activities such as the construction or upgrade of access roads, laydown and maintenance areas, the new substation facility and concrete pouring. Packaging material would be accumulated from unpacking of turbine equipment and off cuts would be produced through various construction activities. General waste would be produced by site personnel including wrapping from food, bottles and cans. Effluent would be produced from toilet facilities (temporary chemical toilets) which would be located onsite for construction workers.

It is anticipated that waste and effluent would be temporarily stored on site before it is removed by an appropriate contractor. There is potential for waste and effluent stored on site to leach into the soil and/ or groundwater, causing harm to the natural environment and potentially contaminating the soil and/ or groundwater. There is a risk that silt and wash water could enter the drainage lines on site.

Box 155.4 Construction Impact: Roggeveld – Waste and Effluent Pollution

Nature: Construction activities that produce waste and effluent would result in a **negative direct** impact on the site.

Impact Magnitude – Low

- **Extent**: The extent of the impact is **onsite** as impact would be restricted to the site.
- **Duration**: The duration would be **short-term** as impacts could persist after the construction of the Wind Farm.
- **Intensity:** The intensity is likely to be **low** as the construction phase is temporary and the site is not inhabited.

Likelihood – It is **unlikely** that waste and effluent generated on site will impact on the soil and/ or groundwater and other site users.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **high.**

Operation Phase Impacts

General waste, such as office waste, and effluent from onsite toilet facilities would be produced during the operation phase of the Wind Farm by onsite personnel. However, this would be limited as there is only likely to be up to 122 permanent personnel on site and a small team of personnel expected during maintenance activities (see Chapter 4).

Maintenance activities may result in the collection of used oil and hydraulic fluid, it is anticipated that this will be temporarily stored on site before being removed by an appropriate contractor. Waste produced during the operation phase would be minimal.

Box 155.5 Operation Impact: Roggeveld Wind Farm–Waste and Effluent Pollution

Nature: Operation activities that produce waste would result in a **negative direct** impact on the site.

Impact Magnitude – Low

- **Extent**: The extent of the impact is **onsite** as impact would be restricted to the site.
- **Duration**: The duration would be **long-term** during the operation of the Wind Farm which will be up to 25 years.
- **Intensity:** The intensity is likely to be **low** as all oils and hydraulic fluids and waste from toilet facilities would be carefully managed and the onsite activities would be limited.

Likelihood – It is **unlikely** that small quantities of spilled oil and hydraulic fluid and small quantities of general waste generated on site from the 20 or so permanent personnel would cause soil or water pollution.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **high.**

15.3.2 Mitigation Measures

The potential impacts associated with the generation of waste and effluent can be minimised through careful mitigation measures, as described below.

Design

- A suitable area for waste skips must be selected, away from water courses, and included in the site layout plan.

Construction

- All waste must be separated into skips for recycling, reuse and disposal;
- Vegetative material must be kept on site and mulched after construction to be spread over the disturbed areas to enhance rehabilitation of the natural vegetation;
- Effluent from temporary staff facilities must be collected in storage tanks, which must be emptied by a sanitary contractor;
- Effluent from concrete washings from the on-site batching plant must be contained within a bunded area;
- All solid and liquid waste materials, including any contaminated soils, must be stored in a bunded area and disposed of by a licensed contractor;
- Effluent and stormwater run-off must be discharged away from any water courses;
- Steel off-cuts must be re-used or recycled, as far as possible; and

- Materials that cannot be re-used or recycled must be placed in a skip and removed from site to a licensed municipal disposal site.

Operation

- Used oil stored on site must be stored in an impervious container, within a bunded area; and

- General waste must be removed from site by a licensed contractor.

15.3.3 *Residual Impacts*

If mitigation measures given above and listed in the EMP are implemented, the overall significance would remain low during the construction phase and negligible during the operational phase of the Roggeveld Wind Farm as outlined in *Table 15.6* below.

Table 155.6. Pre- and Post- Mitigation Significance: Roggeveld Wind Farm – Waste and Effluent

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	**MINOR (-VE)**	**MINOR (-VE)**
Operation	**MINOR (-VE)**	**NEGLIGIBLE**

15.4 HEALTH AND SAFETY LINKED TO CONSTRUCTION AND OPERATION ACTIVITIES

15.4.1 *Impact Description and Assessment*

Potential impacts on construction and operational personnel, and road users likely to arise during the various phases of the Roggeveld Wind Farm development are summarised in *Table 155. 7.* below.

Table 155. 7. Impact Characteristics: Health and Safety

Summary	Construction	Operation
Project Aspect/ activity	Construction activities	Operational activities
Impact Type	Direct, negative impact	Direct, negative impact
Stakeholders/ Receptors Affected	Construction personnel	Landowner, other site users, onsite personnel.

Construction Phase Impacts

Construction activities would involve working with heavy machinery and large turbine components. During the construction phase there would be open excavation and possibly borrow pits on site, heavy vehicles moving on site and large, heavy components would need to be moved across the site, and lifted by a crane. These construction activities are potentially dangerous if not managed appropriately.

There is also potential for construction activities to cause driver distraction amongst road users. The large scale of the construction equipment used to install the wind turbines, together with the unfamiliar sight of such construction may attract driver curiosity and attention.

Box 155.6 Construction Impact: Health and Safety

Nature: The impact on health and safety would be a **direct negative** impact.

Impact Magnitude – Low

- **Extent:** The health and safety risks linked to the construction activities would occur at the **local** level.
- **Duration:** This impact will be for the construction phase, and would therefore be **short-term**.
- **Intensity:** The intensity would be **low** as those who are directly affected would (in most cases) be able to adapt.

Likelihood – It is **unlikely** that accidents would happen on site during the construction phase as potential accidents can be mitigated through a health and safety plan. It is **likely** that road users may become distracted by the sight of turbines being transported along the public roads.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **Medium.**

Operation Phase Impacts

It is recognised that the wind turbines may cause driver distraction among road users where the wind turbines are visible from a public road. This is particularly the case given that there are few commercial wind farms operating in South Africa at present, and the wind farm would be a novelty to many road users. The wind turbines would be visible from the R354 approximately 1-6km km south of the site. Based on the findings of the visual impact assessment (see Chapter 12), it is clear that drivers on the R354 would be able to see the turbines from a distance of approximately 2 km and they would gradually become clearer and more visible the closer one moved toward the Roggeveld Wind Farm. Driver distraction is more severe if the driver cannot see the wind farm upon approach, and as they come around a visual barrier (such as a corner or rise), the wind farm suddenly becomes visible. This is not the case with this site.

During the operation phase there is a danger of turbine failure, which may occur for a number of reasons. One of the most common causes of turbine failure is gear box failure, which can lead to a fire given the flammable nature of the composites used to make the turbines. Structural failure may result in the turbine collapsing or a blade becoming detached and flying off the structure, this is known as "blade throw." If a turbine were to collapse onto a structure or road it could cause damage to property or harm to persons in the immediate vicinity. Modern wind turbines are fitted with electronic monitoring systems within the transmission system to reduce the risks of mechanical failure.

Box 155.7 Operational Impact: Health and Safety

Nature: The impact on health and safety would be a **direct negative** impact.

Impact Magnitude – Low
- **Extent:** The health and safety risks linked to the operational activities would occur **on-site**.
- **Duration:** This impact will occur throughout the operational phase, and would therefore be for the **long-term**.
- **Intensity:** The intensity would be **low** as damage or injury from turbine failure can be mitigated.

Likelihood – It is **likely** that drivers would suffer 'driver distraction' during the operational phase, however given that turbine construction would meet manufacturers specifications, failure of the turbines in **unlikely**.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR (-VE)

Degree of Confidence: The degree of confidence is **high**.

15.4.2 Mitigation

The objective of mitigation is to manage construction and operation so that impacts on health and safety risks to local residents, contractors, employees and animals are reduced.

Design

- Turbines must be spaced at least a turbine and a half's distance from one another so that if one turbine collapses, it does not make contact with the nearest turbine.

Construction

- A health and safety plan must be developed prior to the commencement of construction to identify and avoid work related accidents. This plan must be adhered to by the appointed construction contractors and meet Occupational Health and Safety Act (OHSAct), Act 85 of 1993, requirements;

- Potentially hazardous areas must be clearly demarcated (i.e. unattended foundation excavations); and

- Appropriate Personal Protection Equipment (PPE) must be worn by all construction personnel.

Operation

- Regular maintenance of turbines and all other infrastructure must be undertaken to ensure optimal functioning and reducing the chance of gearbox failure; and

- Regular inspections of the turbine foundations, towers, blades, spinners and nacelle must be undertaken in order to check for early signs structural fatigue.

15.4.3 *Residual Impact*

The implementation of the above mitigation measures would reduce the construction and operation impacts from minor to negligible. The pre- and post-mitigation impacts are compared in *Table 155.156*.

Table 155.156 Pre- and Post- Mitigation Significance: Health and Safety

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	**MINOR (-VE)**	**NEGLIGIBLE**
Operation	**MINOR (-VE)**	**NEGLIGIBLE**

15.5 SHADOW FLICKER

15.5.1 *Impact Description and Assessment*

Under certain light conditions the moving shadow cast by revolving wind turbine blades can result in a flickering effect. This transient effect is known as shadow flicker and is experienced on the ground or inside dwellings with narrow aperture windows when the direction and angle of incident sunlight align. Shadow flicker is not a concern during the construction phase as it only has the potential to occur during operation of a Wind Farm.

Table 155.6 Impact Characteristics: Shadow Flicker

Summary	Construction	Operation
Project Aspect/ activity	N/A	Operation of wind turbines
Impact Type	N/A	Direct negative
Stakeholders/ Receptors Affected	N/A	Affected landowners or those living on site

Operation Phase Impacts

Shadow flicker can be a nuisance, particularly when the receptor is in a building, as the contrast between light and shade is most noticeable through windows and doors. Flickering and strobing can potentially trigger an epileptic fit in cases of photosensitive epileptic. A survey carried out by Epilepsy Action (1) in the UK, concluded that wind turbines may create circumstances where photosensitive seizures can be triggered, however it does appear that this risk is minimal. Furthermore they state that "*newer wind turbines are usually built to operate at a frequency of 1 Hz or less. These flicker rates are unlikely to trigger a seizure.*" (2)

(1) Epilepsy Action online, available at http://www.epilepsy.org.uk/campaigns/survey/windturbines
(2) Epilepsy Action online, available at http://www.epilepsy.org.uk/info/photosensitive/triggers

The following physical circumstances need to apply simultaneously before shadow flicker can occur:

- the receptor must be within 10 turbine diameters of the turbine;
- there must be a sufficient level of sunlight;
- the wind turbine must be operating (wind speeds must therefore be at least about 2.5m s^{-1});
- the moving shadow cast by rotating blades must be seen from within a building, particularly when viewed through a narrow window;
- the orientation of the turbine and its angle of elevation to the observer must coincide with the angle and the position of the sun in relation to the building so that the shadow falls onto the receptor; and
- since the origin of the effect is the sun, receptors that may be affected must lie to the south of the point where the sun rises and sets.

Where these circumstances pertain, the exact position of shadows can be calculated very accurately for each sensitive location for the key times of day and year to determine the potential for shadow flicker. The turbine diameter for the proposed Wind Farm would be approximately 117 m. A receptor would therefore need to be 900 m from the turbine to experience shadow flicker.

Box 155.8 Operational Impact: Shadow Flicker

Nature: The impact of shadow flicker would be a **direct negative** impact on people within dwellings.

Impact Magnitude – Low

- **Extent:** The shadow flicker would occur at the **onsite** level, as this impact would impact people within dwellings located within a 1 km radius of the proposed turbines.
- **Duration:** This impact would be **long-term** throughout the operational phase of the Wind Farm, 25 years.
- **Intensity:** The intensity would be **medium** as the dwellings are places of residence.

Likelihood – It is **unlikely** that this impact would occur during the operational phase, as the dwellings are located over 1km south of the proposed turbine locations.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE

Degree of Confidence: The degree of confidence is **medium** as the exact locations of the proposed turbines have not as yet been micro-sited.

15.5.2 *Mitigation*

A shadow flicker study will be required if the final turbine layout results in turbines being located within 10 blade diameters of any dwellings or buildings within which people live or work. Mitigation may include re-siting the relevant turbines or planting indigenous trees to provide screening in front of windows or glass panelled doors.

Table 155.7 Pre- and Post- Mitigation Significance: Shadow Flicker

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Operation	**NEGLIGIBLE**	**NEGLIGIBLE**

15.6 ELECTROMAGNETIC INTERFERENCE

Electromagnetic interference is not a concern during the construction phase and can only occur during the operation of the Wind Farm, when the turbines are in operation. Note: Some information gaps exist that will only become available once a final supplier has been identified.

Table 155.8 Impact Characteristics: Electromagnetic Interference

Summary	Construction	Operation
Project Aspect/ activity	N/A	Operation of the wind turbines
Impact Type	N/A	Direct negative
Stakeholders/ Receptors Affected	N/A	Users of communication systems

Operation Phase Impacts

Operating wind turbines can cause electromagnetic interference (EMI). This can potentially affect communication systems including TV, radio and mobile phone transmitters, microwave links, radar and aircraft navigation beacons.

For broadcast systems, such as television, a wind farm located between a television transmitter and a receiver aerial may cause loss of picture detail, loss of colour or buzz on sound. Viewers situated to the side of a wind farm may experience a delayed image or 'ghost' on the picture, liable to flicker as the blades rotate. In some cases, a wind farm can also affect the re-broadcast link (RBL) feeding the transmitter.

Broadcast radio transmissions are received at radio receivers after radio signals have travelled through free space and often through structures. Because of this method of transmission and reception, it can be concluded that the proposed wind farm would have no detrimental effects on national or local radio in the vicinity of the proposed development.

There is the potential for rotating turbine blades to generate unwanted returns on air traffic control and defence radar displays. This may affect wind turbine developments as much as 75 km away from a radar site.

The potential for interference is dependent on the positions of turbines in relation to incoming or outgoing signals as well as the specific characteristics of the signal. In addition, the nature of the material of the turbine rotors would result in impacts of varying magnitude i.e. those constructed of composite materials which have reduced potential for signal interference in comparison with metal blades. Following advice from ERM, G7 has identified potential interested and affected parties and consulted with them in order to identify the potential impacts associated with electromagnetic interference at and around the Roggeveld site. The following service providers have been consulted with:

- Department of Defence;
- Eskom;
- MTN;
- SA Police;
- Sentech;
- Transnet;
- Telkom; and
- Vodacom.

To date, these service providers consulted have not highlighted any serious concerns although some are currently undertaking their own studies and awaiting results. G7 are aware that the possibility of interference although not expected to be an issue, can not be ruled out. Due to concerns and requests from stakeholders, G7 is undertaking a separate EMI study, which may inform further mitigatory measures. During the operational phase, should interference occur, G7 would establish procedures to investigate any complaints of interference through an effective Grievance Procedure (See *Chapter 14*). G7 have committed to correct any EMI impacts if it is shown that the Wind Farm is responsible.

15.7 CLIMATIC EFFECTS

The potential impacts of wind farms on regional and local climatic conditions are presently poorly understood and little scientific research has been conducted in this regard. ERM has undertaken further extensive research for peer reviewed studies assessing and evaluating potential impacts on micro- and regional climate from wind farm developments. In excess of 15 key authors in this field of research were established and research studies interrogated. The research study articles are referenced in Chapter 19. (These studies do not include potential positive impacts related to reduced carbon production and prevention of global warming effects in the simulation models, however, reference is made that such potential positive impacts not to be ignored or overlooked).

The generation of electricity using wind turbines is percentage-wise the fastest growing energy resource globally among current energy technologies with low or zero greenhouse gas (GHG) emissions (Wang and Prinn, 2010). Most of this growth is in the industrial sector, based on large utility-scale wind farms. Debates exist regarding the global-scale effects of wind farms; however, modelling studies indicate that wind farms can affect local-scale meteorology (Baidya Roy and Traiteur, 2010).

Solar energy absorbed by the Earth is converted into various forms of energy; namely latent heat (by evaporation), gravitational potential energy (by atmospheric expansion), internal energy (by atmospheric and oceanic warming, condensation) or kinetic energy (such as convective and baroclinic instabilities). If averaged globally, total atmospheric energy is comprised of the following percentages:

- Internal energy – 70.4 percent
- Gravitational potential energy – 27.05 percent
- Latent heat – 2.5 percent
- Kinetic energy – 0.05 percent

Of the already relatively lower percentage of kinetic energy, only a small fraction is contained in the near surface winds that produce small-scale turbulent motions due to surface friction. These turbulent motions further downscale to molecular motions, and thus convert bulk air kinetic energy to internal energy. However, in considering the question of potential climatic impacts from wind farms, it is not the size of these energy reservoirs, but rather the rate of conversion from one to another that is more relevant. According to Wang and Prinn's (2010) model calculations, the global average rate of conversion of large-scale wind kinetic energy to internal energy near the surface is approximately 1.68 W/m^2 (860 TW globally). This only constitutes approximately 0.7 percent of the average net incoming solar energy of 238 W/m^2 (122 PW globally). The magnitude of this rate in the presence of wind turbines is expected to differ, but not by large factors (Wang and Prinn, 2010).

Wind turbines function by converting wind power into electrical power. Turbulence near the surface, however, also feeds on wind power. This turbulence is critical for driving the heat and moisture exchanges between the surface and the atmosphere, which play an important role in determining surface temperature, atmospheric circulation and the hydrological cycle (Wang and Prinn, 2010). The rate of energy extraction by wind farms from the atmosphere (approximately 1 W/m^2), although small compared to the kinetic and potential energy stored in the atmosphere, is comparable to time-tendency terms, for example the rate of conversion of energy from one form to another and frictional dissipation rate in the atmospaheric energy balance equation. This indicates that influence to atmospheric and surface processes by wind farms is possible (Baidya Roy et al., 2004).

15.7.1 Potential Impacts on Local Climate

In a modelling study conducted by Baidya Roy et al. (2004), results indicated that the modelled wind farm significantly slowed down the wind at the turbine hub-height level. In addition to this, the turbulence generated in the wake of the rotors create eddies that can enhance vertical mixing of momentum, heat and scalars, usually leading to a warming and drying of the surface air and reduced surface sensible heat flux. The effect was found to be most intense during the early morning hours when the boundary layer is stably stratified and the hub-height level wind speed is the strongest due to the nocturnal low-level jet. The impact on evapotranspiration was found to be small.

A recent study conducted by Baidya Roy and Traiteur (2010), using field data and numerical experiments with a regional climate model, potential impacts of wind farms on surface air temperatures was investigated. Data showed that near-surface air temperatures downwind of the wind farm are higher than upwind regions during night and early morning hours, while the reverse held true for the rest of the day. Therefore the wind farm investigated has a warming effect during the night and a cooling effect during the day. Baidya Roy and Traiteur (2010) proposed an explanation for this using the hypothesis put forward in the Baidya Roy et al. (2004) work, that turbulence generated in the wake of the rotors enhance vertical mixing. Under stable atmospheric conditions when the lapse rate is positive, i.e. a warm layer overlies a cool layer, the enhanced vertical mixing mixes the warm air down and cooler air up, leading to a warming near the surface. While under unstable atmospheric conditions with a negative lapse rate, i.e. cool air lying over warmer air, the turbulent wakes mix cool air down and warm air up, thereby producing a cooling effect near the surface. The atmospheric model used supported the field data findings. The model simulations additionally indicated that the temperature change in wind farms was also a function of the mean ambient hub-height (second atmospheric layer) wind speed. Weaker impacts were found at higher wind speeds. Two factors may lead to this. Firstly, at wind speeds higher than 20m/s the rotors are designed to stop working. If average wind speed is high, it is likely that instantaneous wind speeds frequently exceed 20m/s, hence the rotors work only intermittently, reducing the mean impacts on the surface temperatures. Secondly, at high wind speeds the ambient turbulence is also relatively high, resulting in lower impacts.

Baiyda Roy and Traiteur (2010) state that as many of the wind farms are located on agricultural land, the impacts from wind farms on surface meteorological conditions are likely to affect agricultural practices, in some cases the impacts may be beneficial such as the nocturnal warming under stable atmospheric conditions protecting crops from frost. They additionally state that if the wind farms are sufficiently large, they may also affect downstream surface meteorology.

In response to the Baiyda Roy and Traiteur (2010) study, Bruce Bailey of AWS Truepower states that turbines in use today are technologically more advanced than the ones used in the study and differ in dimensions. Additionally, the spacing between turbines is different, currently being spaced at least five times wider apart than those used in the study. Wind developers are already taking the temperature effect into account because of the impact of the 'upstream' turbines buffeting the wind on 'downstream' turbines. Seemingly many wind farm projects map multiple weather data, including temperatures, and are aware of this effect (Biello, 2010).

Baiyda Roy and Traiteur (2010) put forward two options for reducing the above mentioned effects. One option is to have turbines designed to reduce the turbulence generated by the rotors. Rotors that generate more turbulence in their wakes are likely to have a stronger impact on near-surface air temperatures. The second option is to look for optimal siting solutions for wind farms. Taking their study findings into consideration, the impact of wind farms starts decreasing sharply as ambient surface kinetic energy dissipation rate becomes larger than 2.7 W/m^2 and becomes almost zero at dissipation rates higher than 6 W/m^2. Therefore, generally, the more turbulent the site is naturally, the lower the potential impact on surface temperatures by an introduced wind farm. As Biello (2010) states, it is in these naturally turbulent areas that wind farms tend to be located, as that is often where the wind is strongest.

15.7.2 *Potential Impacts on Global Climate*

There is currently a debate regarding the potential effects of large-scale wind farms on climate at a global scale. A study of climate –model simulations that addresses the possible climatic impacts of wind power at regional to global scales by using two general circulation models and several parameterizations of the interaction of wind turbines with the boundary layer by Keith et al. (2004) found that large-scale use of wind farms can alter local and global climate by extracting the kinetic energy and altering turbulent transport in the boundary layer. The study found that very large amounts of wind farm power generation can produce 'non-negligible' climatic change at continental scales. However, although large-scale effects are observed, the overall effect on global-mean surface temperature is negligible.

Barrie and Kirk-Davidoff's (2010) General Circulation Model study, representing a continental-scale wind farm as a distributed array of surface roughness elements, showed that the extensive installation of wind farms would alter surface roughness and significantly impact the atmospheric circulation due to the additional surface roughness forcing. The model showed that disturbances caused by a step change in roughness grew within four and a half days, such that the flow is altered at synoptic scales. The authors recognize that wind farms on this scale do not exist, and as such view the work as a theoretical problem, with real applications in decades to come.

A further study conducted by Wang and Prinn (2010), using a three-dimensional climate model simulating the potential climate effects associated with the installation of wind turbines over large areas of land or coastal ocean, showed that in meeting 10 percent or more of the global energy demand in 2100 (approximately 140 EJ/year (4.4TW)), surface warming exceeding 1°C over land could be caused. While in contrast, surface cooling exceeding 1°C was computed over ocean installations. Significant warming or cooling remote from the land and ocean installations, and alterations of the global distributions of rainfall and clouds also occurred in the model simulations.

The obvious critique of the above studies is that they are purely theoretical and based on simulation models. These models are dependent on the accuracy of the model used and the realism of the methods applied in order to simulate the wind turbines (Wang and Prinn, 2010). Baiyda Roy in considering the question of climatic impacts on a global scale remains sceptical, stating that a subsequent study awaiting publication, indicates that these climatic impacts are restricted to a small area around the wind farms. Additionally stating that although the above studies indicate large scale wind farms having global climatic effects, if the wind farms are spaced sufficiently apart, they will not cause global scale effects (Baiyda Roy in Biello, 2010).

It should be noted that preliminary calculations using assumptions common in the models used by Keith et al. (2004), consistently show that by reducing CO_2 emissions, the indirect benefits of wind farms exceed the costs (or benefits) of use from their direct climatic effects. Therefore the greatest potential climatic impact on a global level may be the reduction of CO_2 in the atmosphere.

15.7.3 Conclusions

Modelling studies on the cumulative climatic effects of wind farms over entire countries or regions are inconclusive. On a local scale, only one known published modelling study has been supported by data collected in the field, but research suggests that wind farms have the potential to alter local-scale climatic conditions, and temperature in particular (Baidya Roy and Traiteur, 2010). It is reported that wind turbines and resulting changes to air flow patterns can alter local surface air temperatures, which may in turn alter local patterns of evaporation. It is not clear whether these changes are likely to have significant or noticeable impacts on local climatic conditions and site specific conditions are likely to play a major role in whether micro-climatic effects may occur.

The potential significance of micro-climatic effects due to wind farms is currently unclear and further research is required to understand ecosystem level effects. In such a study, the following aspects should be considered within an integrated research programme; microclimatic changes, insect and pollination effects and other trophic level effects. This should not be coordinated by G7 but by a research institute. Although such research falls beyond the scope of this EIA, G7 could possibly provide support to such a study. In order to contribute to longer term understanding, certain climatic data should be collected on site and at a control site to assist with interpreting additional data that is collected.

CONTENTS