



VelantisWind

Noise Module Guide

User manual, inputs, calculation methodology and interpretation criteria

This guide describes how the VelantisWind noise module works, the supported input formats, preparation of layers and parameters, the calculation workflow and interpretation of results. It includes practical explanations of receivers, DEM/DSM, land use and the treatment of acoustic terms aligned with ISO 9613-2.

Main contents

- General module configuration and workflow in QGIS.
- Input formats: sources, receivers, spectrum, DEM/DSM and land use.
- Equations, physical model, approximations and variable traceability.
- Outputs, result review and final validation checklist.



Contents

This guide is intended as a technical document for use and traceability of the VelantisWind noise module. It first explains the inputs and workflow in QGIS; it then develops the equations, physical interpretation and outputs that allow the calculation to be audited.

Block	Pages	What it provides to the user
A. Use and inputs	3-44	Minimum workflow, Refresh, layer selection, turbine layout, acoustic emission, receivers, DEM/DSM, land use, GIS outputs and practical checklist.
B. Model equations	45-56	Mathematical structure of the calculation: 3D geometry, octave bands, Adiv, Aatm, Agr/G_eff, Abar, energy summation, raster and isophones.
C. Physical interpretation	57-70	Correct reading of each term: what the module actually calculates, which simplifications it applies and how to interpret atmosphere, ground, DEM, screening and source summation.
D. Technical appendix	71-91	Supporting material for technical review and auditing: variables, output fields, diagnostics and the relationship between inputs, equations and results.
E. Scope and final validation	92-97	Public scope text, model limitations, final checks and recommendations for presenting the module without overstating regulatory certification.

Recommended reading: for a first use, Block A is sufficient. To technically justify a result, also review Blocks B and C. For delivery or publication, close with Block E.



1. The simplest way to use the module

This workflow avoids mixing advanced options at the beginning. It is used to confirm that the layout, receivers and CRS are correct before enabling a DEM, land use, spectra or a fine map.

Step	User action	Expected result
1	Open a QGIS project using a metric CRS for the site. Example: UTM / EPSG:25830 for the test case.	Distances are calculated in metres. Avoid working in latitude/longitude.
2	Load or import the turbine layout. If it already comes from Energy/AEP, reuse it. Otherwise use Import layout CSV.	A point layer appears in VelantisWind - Turbine layouts.
3	Create a point receiver layer: one point per dwelling, settlement, farm or sensitive location. Optional fields: id, name, type.	The layer appears in Receiver layer after pressing Refresh.
4	Press Refresh when opening the module or after loading new layers.	Sources / acoustic layout, Receiver layer, DEM/DSM and land use are updated.
5	Select the sources and receiver layer. Keep a global height of 4 m and a global limit of 45 dB(A) for the first test.	A basic case with one receiver layer is configured.
6	Use the Fast engine and a fixed LwA per source group. Review the acoustic source-group table.	Quick calculation to detect input errors.
7	Press Check configuration and then Calculate noise.	Noise - Receivers, Sources, Dominant links and, if enabled, Map/Isophones are created.

Practical rule. Do not enable everything at once. First calculate without a DEM, without land use and without a fine raster. Once the basic result is coherent, enable ISO-aligned, DEM/DSM, land use, an LwA(ws) curve or an OEM spectrum.

2. Refresh: when to load layers and when to press it

The module reads the layers already loaded in the QGIS project. If you create or add a layer after opening the module, it may not yet appear in the drop-down list. In that case, press Refresh.



Refresh button in the main plugin hub.

What Refresh does. Reloads the module's internal lists: sources/layouts, receivers, DEM/DSM and land use. It does not recalculate, change parameters or restart QGIS.

Recommended sequence: load layers in QGIS -> open the Noise module -> Refresh -> select layers -> Check configuration -> calculate noise.

Typical case	Correct action
Import a layout CSV	Refresh and tick the layer in Sources.
Create receiver points	Refresh and choose the layer in Receiver layer.
Load a DEM/DSM raster	Refresh and select DEM/DSM.
Add land use	Refresh and select the layer in Land-use layer.



3. Inputs: minimum, recommended and advanced

The module can operate with very little data, but traceability increases when a DEM, land use and manufacturer acoustic data are added.

Use level	Required inputs	When to use it	Caution
Minimum	Turbine layout + receiver layer + fixed LwA + metric CRS.	Initial screening, installation test, identification of critical receivers.	Does not represent topography or band-by-band spectral variation.
Recommended	Minimum + DEM/DSM + correct radius + ISO-aligned engine + atmospheric conditions.	More defensible technical review and diagnostics of Adiv, Aatm, Agr and Abar.	The DEM must use the same CRS and have no problematic NoData.
Advanced	Recommended + land use with G + LwA(ws) curve + OEM octave-band spectrum + several receiver categories.	Comparison with other software, reports, day/night scenario analysis.	Check that an absolute spectrum has not been normalised by mistake when it should be used as supplied.

Inputs that are not mandatory. You do not need a WRG, electrical power curve, Ct or AEP to calculate noise. The noise module uses turbine positions, heights, acoustic emission, receivers and propagation. Energy/AEP information only helps reuse layouts that are already loaded.



4. Where each input is selected in the interface

This page summarises what each control in the module expects.

Module control	Expected layer or data
Sources / acoustic layout	Detected or imported turbine point layers. One or more can be selected.
Receiver layer	Point or polygon vector layer. Points are recommended.
Use multiple layers by category	Allows several receiver layers with type, day/night limits and height configured in the table.
DEM / DSM	Elevation raster in the same CRS as the project. Optional, but strongly recommended.
Land-use layer	Polygon layer with a numeric G factor or a text land-use class.
Acoustic scenario	Fixed LwA or an LwA(ws) acoustic curve per source group.
Calculation engine	Fast for screening; ISO-aligned for bands, atmosphere, Agr and Abar.

Recommended sequence. 1) Load layers in QGIS. 2) Open the Noise module. 3) Press Refresh. 4) Select sources, receivers, DEM/DSM and land use. 5) Review acoustic groups and limits. 6) Run Check configuration. 7) Calculate noise.

Calculation parameters panel (configuration example)

Reproduction of the module configuration panel with example values. The ISO-aligned method corresponds to ISO 9613-2 with octave bands (Adiv + Aatm(T,RH,P) + Agr(f)).

Receiver height [m]: 2.0 mMaximum radius [m]: 5000 m

DEM / DSM (optional): MDT02-ETRS89-HU30-0311-1-COB2

Map resolution [m]: 100 mGenerate isophones

Isophone levels [dB(A)]: 35,40,45,50Receiver limit [dB(A)]: 48.0 dB(A)

Linear attenuation α [dB/m]: 0.0050Ground factor G: 0.85

Ground mode: Global (manual G)Land-use layer (optional): Sin capa de uso del suelo

Método ISO-aligned: ISO 9613-2 con bandas de octava (Adiv + Aatm(T,RH,P) + Agr(f))

Calculation engine: ISO-aligned - octave-band ISO 9613-2

Atmospheric conditions (ISO engine)

Temperature, humidity and pressure used by the ISO-aligned engine.

Temperature: -12.0 °C

Relative humidity: 49.0 %

Atmospheric pressure: 109.000 kPa

Use typical site conditions. If you do not have measured pressure, 101.325 kPa is a standard sea-level reference; at altitude it is usually lower.

Noise module configuration panel.

Parameter	Example value
Receiver height [m]	2.0 m
Maximum radius [m]	5000 m
DEM / DSM (optional)	MDT02-ETRS89-HU30-0311-1-COB2
Map resolution [m] · Generate isophones	100 m · []
Isophone levels [dB(A)]	35,40,45,50
Receiver limit [dB(A)]	48.0 dB(A)
Linear attenuation α [dB/m]	0.0050 (Fast engine only)
Ground factor G · Ground mode	0.85 · Global (manual G)
Land-use layer (optional)	— No land-use layer —
Calculation engine	ISO-aligned · octave-band ISO 9613-2
Temperature / RH / Pressure (ISO)	-12.0 °C · 49.0 % · 109.000 kPa

Note: use typical site conditions. If measured pressure is unavailable, 101.325 kPa is the standard sea-level reference; at altitude it is usually lower.

Important. Check configuration is not decorative: it validates layers, CRS, parameters and acoustic configuration before execution. Use it after every input change.



5. Source input: turbine layout

Each turbine is a point source. The module needs X,Y coordinates and a hub height associated with the source group. You can reuse Energy/AEP layouts or import a new one from CSV.

Recommended minimum CSV

```
x,y
356123.40,4640123.80
356850.00,4640740.20
357420.50,4641310.75
```

Data	How it is used
X,Y	Horizontal distance, radius filtering, source-receiver line, effective G and DEM profile.
Model / group	Groups turbines sharing the same acoustic configuration: LwA, curve and spectrum.
HH [m]	Acoustic source elevation: $z_{\text{source}} = \text{terrain} + \text{hub height}$.
D [m]	Informational and model-traceability data; it does not replace LwA.
Fixed LwA	Global sound power when no LwA(ws) curve is used.

Coordinate	Accepted names
X	x, utm x, easting, east, lon, longitude
Y	y, utm y, northing, north, lat, latitude

CRS and units. Although the reader accepts names such as lon/lat, the calculation does not reproject coordinates inside the CSV. Use metric coordinates in the project CRS. If latitude/longitude values are pasted into a UTM project, the distances will be wrong.

6. Acoustic emission by source group

Each row in the group table defines an acoustic group. All turbines in that group share hub height, diameter, fixed LwA, acoustic curve and OEM spectrum.

Mode	Input	Interpretation
Fixed LwA	Value in dB(A) in the table.	Used directly as the global sound power of the group.
LwA(ws) curve	CSV with wind speed and LwA.	The plugin interpolates at the evaluation speed or takes the worst case if the box is enabled.
Absolute OEM spectrum	CSV by octave band.	If it is not normalised, the operating LwA becomes the A-weighted sum of the spectrum.
Normalised spectrum	Normalize box enabled.	The spectrum only supplies its shape; it is shifted to reproduce the group LwA.

Acoustic scenario: i

Fixed LwA by source group

Evaluation speed [m/s]: i

29.0

☐ Use curve worst case

In curve mode, each source group can use a different ws/LwA CSV.

Acoustic source-group configuration

Review the acoustic emission assigned to each source group before running the calculation. i

Source group	Wind farm	Base model	Turbines	HH [m]	D [m]	Fixed LwA [dB(A)]	CSV curve	Notes
Vestas V90-2...		Vestas V90-2.0 ...	75	80.0	90.0	105.0 dB(A)	—	Model=Vesta...

Import acoustic curve for selected source group...

Clear curve from selected source group

Import OEM spectrum (octave-band CSV) for the selected source group...

Edit spectrum of the selected source group...

Clear spectrum of the selected source group

☐ Normalize the spectrum to the group LwA (from above only)

Acoustic scenario panel and source-group configuration table (example: Vestas V90-2.0, 75 turbines, HH 80.0 m, D 90.0 m, fixed LwA 105.0 dB(A), evaluation speed 29.0 m/s), including controls to import/edit an LwA(ws) curve and OEM spectrum and the normalisation option.



7. LwA(ws) curve and OEM spectrum formats

LwA(ws) acoustic curve

```
wind speed,lwa
6,101.5
7,103.0
8,104.2
9,105.0
10,105.5
```

Rule	Detail
Columns	The first two numeric columns are read: speed [m/s] and LwA [dB(A)].
Separators	Comma, semicolon, tab or space. Decimal comma is accepted.
Duplicates	If several rows exist for one speed, the maximum LwA is retained.
Outside range	The nearest endpoint is used. No extrapolation.

OEM spectrum by band

```
freq hz,Lw dB
63,92.0 125,96.0
250,99.0 500,101.0
1000,102.0 2000,101.0
4000,98.0 8000,93.0
```

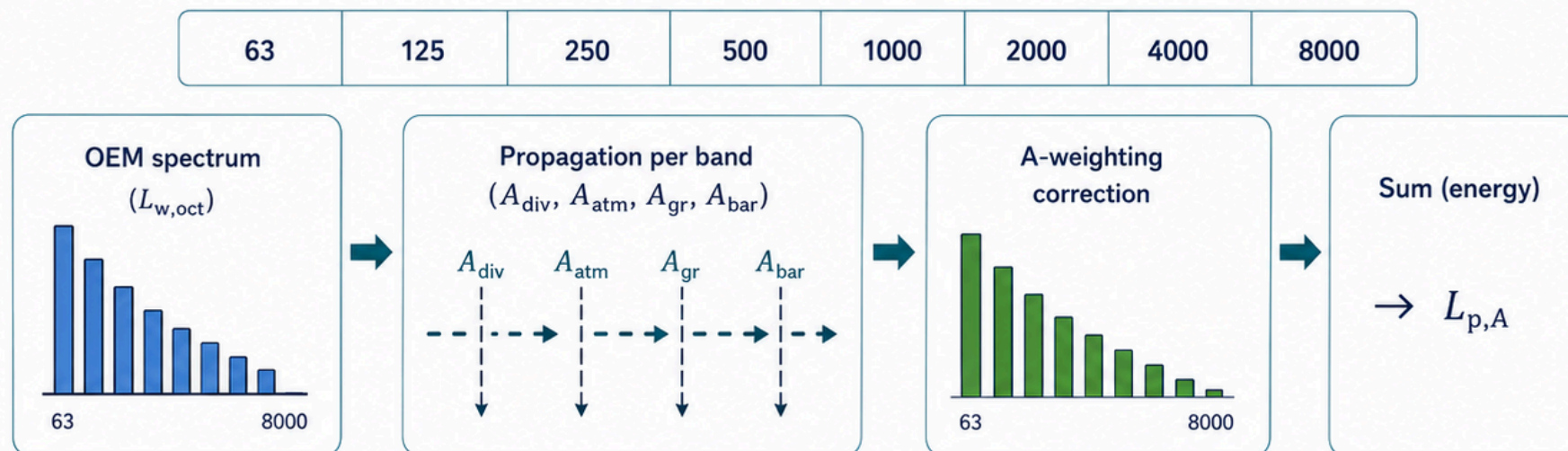
Field	Accepted headers
Frequency	freq hz, frequency, freq, hz, f, band, band hz
Absolute Lw	Lw dB, Lw, level, dB, Lw band
Band LwA	LwA dB, LwA, dBA, dB(A), Lw dBA
Relative shape	Lw dB rel, Lw rel, relative, rel, s b, shape

Do not mix formats. The LwA(ws) curve is not an electrical power curve. The OEM spectrum is not Ct or power. The curve defines a global LwA for each speed; the spectrum distributes the acoustic energy among bands.

B3 visual. Frequency bands and spectrum

The module transforms the source spectrum into A-weighted levels at the receiver by applying propagation losses and A-weighting in each octave band, then summing energetically.

Example 1/1 octave bands (Hz)



Spectrum options in the module



The module can output A-weighted global level and the spectrum per band at each receiver or raster cell.



8. Receivers: recommended layer format

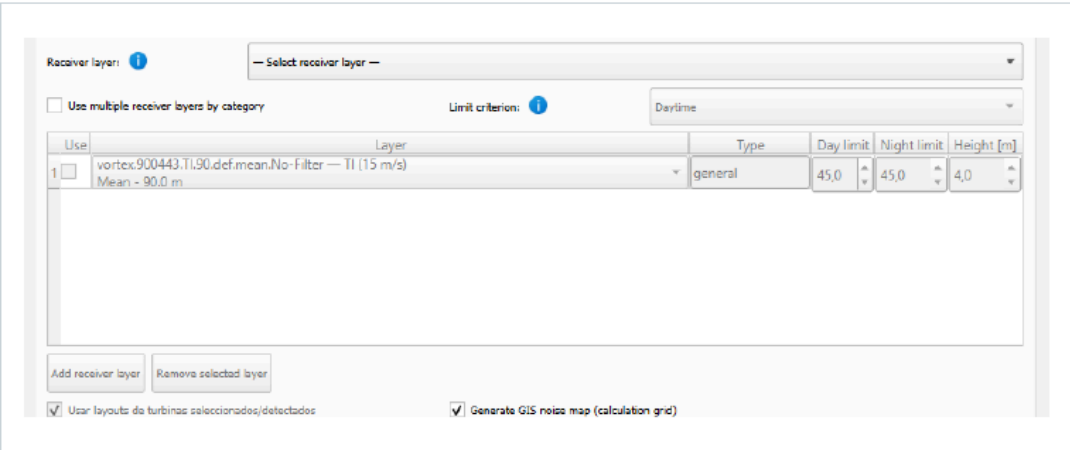
A receiver is the point at which the sound level is evaluated. The most robust option is a point layer: one point for each dwelling, isolated building, settlement, farm or sensitive location.

Element	Recommended format	How the module interprets it
Geometry	Point / MultiPoint converted to simple points if necessary.	The point is evaluated directly. eval_mode = point.
CRS	Same CRS as the project and turbine layout.	If it differs, Check configuration stops the calculation.
Minimum fields	None are mandatory in simple mode.	Original attributes are preserved in the output, but the limit and height are global.
Useful fields	id, name, type, municipality, notes.	They help identify results but do not change the physics in single-layer mode.
Height	Receiver height [m] control, default 4 m.	Added to DEM terrain: $z_{receiver} = z_{terrain} + height$.
Limit	Receiver limit [dB(A)] control, default 45 dB(A).	Compared with noise_dba to calculate margin_db, exceeds and state.

Minimum receiver GeoPackage format. Layer: receptores_puntos. Geometry: Point. CRS: project UTM. Optional fields: integer rec_id, text name and text type. In simple mode, no limit or height field is required.

9. How receivers are read and interpreted

The receiver is the point where the sound level is evaluated. If the layer contains polygons, the module uses a representative point to calculate distances, DEM and source-receiver contributions.



Receiver layer panel with multiple layers by category: Type, Day limit, Night limit and Height per layer; Add/Remove receiver layer buttons; and options to use selected/detected turbine layouts and generate a GIS noise map.

Input case	Evaluated point	Traceability
Point	Original point coordinate.	eval_mode = point.
Polygon	Geometry centroid.	eval_mode = centroid. This should be documented.
Empty or invalid geometry	Omitted.	It does not enter the calculation list.
DEM available	z_ground is sampled at the evaluated x,y point.	rec_z_m and rec_ac_z_m in outputs.
No valid DEM	z_ground remains unavailable or a fallback is used depending on engine/raster.	Abar may have no DEM or no valid profile.
No sources inside radius	Level 0, covered = 0.	Added to Noise - Receivers outside radius.

Key idea: the calculation does not evaluate continuous areas. It evaluates a finite list of receiver points. If polygons are loaded, the module uses the centroid as the representative point.



9b. Recommendation for polygons

Supplement to the previous table for polygon receiver layers.

Recommendation for polygons. For settlements or parcels, create representative points manually when the centroid does not represent the sensitive location well. A geometric centroid can fall in an unrepresentative area.

When the settlement edge or facade matters, generate points along the boundary or at representative sensitive locations instead of relying on the polygon centroid.



10. Simple mode vs multiple receiver layers

This is one of the most important clarifications: in simple mode the layer does not need special fields. In category mode, limits and heights are assigned from the interface table.

Mode	How it is configured	Fields actually read	Recommended use
Single layer	Select one layer in Receiver layer. Disable Use multiple layers by category.	Height/limit fields are not read from the layer. The global Receiver height and Receiver limit are applied.	Initial screening or all receivers using the same criterion.
Multiple layers by category	Enable the option, add layers and define Type, Day limit, Night limit and Height in the table.	The plugin creates an internal layer with grp_type, grp_h_m, grp_lim_d, grp_lim_n, grp_lim_c and grp_src. Those internal fields are used.	Dwellings, farms, industrial, environmental or other categories with different limits.
Already attributed layer	If you have your own night-limit or height fields, they are not mapped automatically by the current UI.	With the current interface, use category mode or adapt the data to the internal workflow.	Avoid assuming that a field is applied merely because it exists in the GPKG.

Limit criterion. Manual/global uses the general limit. Daytime or Night-time uses the values configured per layer in the category table. It does not change physical propagation; it only changes the compliance assessment.

A12. Receiver categories and compliance

How receiver layers, limits and heights are interpreted when evaluating compliance.



Simple mode

One receiver layer is selected, one global receiver height is applied, and one global limit is used for all receptors.



One selected receiver layer



Global height applied to all



Global limit applied to all



Good for first screening



Best when all receptors follow the same evaluation criterion.



Category mode

Multiple layers can be added and each layer receives its own Type, Day limit, Night limit, and Height in the interface table.



Several receptor layers



Type per layer



Day / night limit per layer



Height per layer

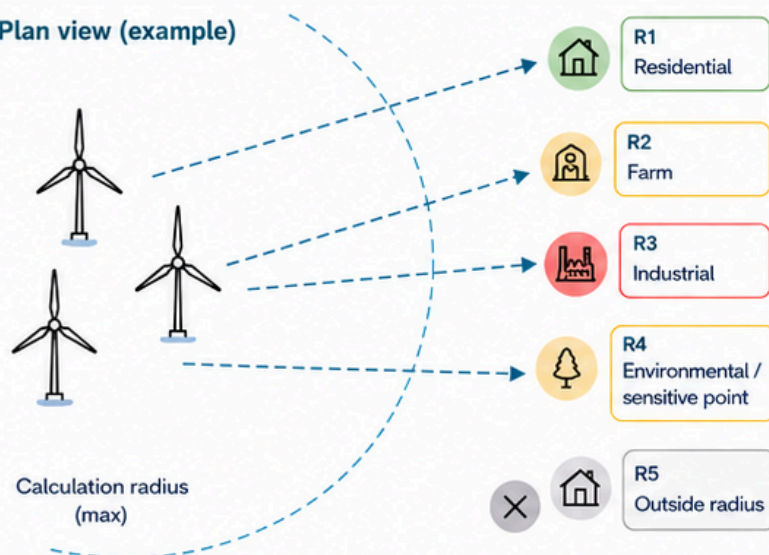


Good for residential, farms, industrial, environmental categories



The module applies compliance by the selected criterion, not by free-form fields in the source layer.

Plan view (example)



$$\text{margin} = \text{limit} - \text{noise_dba}$$

state = pass if margin >= 0; exceed if margin < 0

Status legend

- Pass
- Near limit
- Exceedance
- Outside radius / not covered



Covered receptors receive a calculated level and a compliance state. Receptors with no sources inside the radius are reported separately.

Receptor	Type	Noise dB(A)	Limit	Margin	State
R1	Residential	43.2	45.0	+1.8	● Pass
R2	Farm	46.8	46.0	-1.8	● Exceedance
R3	Industrial	47.5	50.0	+2.5	● Pass
R4	Sensitive point	39.5	40.0	+0.5	● Near limit



Interpretation rule

Simple mode is ideal for quick screening. Category mode is preferable when different receptor families must be checked against different limits or heights.



11. Scenarios: what changes and what does not

The module contains two distinct ideas that should be kept separate: the turbine emission scenario and the receiver limit scenario.

Scenario type	Interface control	What it changes	What it does not change
Source acoustic scenario	Acoustic scenario: fixed LwA by group or LwA(ws) curve. Evaluation speed and Use curve worst case.	Defines the operating LwA of each source group. With a curve, it interpolates at the evaluation speed or uses the maximum when worst case is enabled.	Does not change receivers, limits, DEM or land use. Only the propagated emission changes.
Spectral scenario	Import OEM spectrum and Normalize spectrum.	Defines how sound is distributed among octave bands in the ISO engine. An unnormalised absolute spectrum can redefine operating LwA.	Does not change turbine positions or the compliance criterion.
Receiver limit scenario	Limit criterion: Manual/global, Daytime or Night-time.	Selects the limit compared against noise_dba: global limit or day/night limit configured per receiver layer.	Does not change the calculated level. Only limit_dba, margin_db, exceeds and state change.

Key message. Changing the acoustic scenario can change the calculated noise. Changing only the limit criterion does not change noise_dba; it changes the margin to the limit and whether the receiver is shown as exceeding it.



12. When to use multiple receiver layers

Multiple-layer mode is intended to separate receiver families assessed using different criteria. It is not required for a simple calculation.

Situation	Recommended mode	Why
All receivers have the same limit and height.	Single layer.	Faster to configure and less prone to error. Uses the global limit and global height.
Dwellings and sensitive locations have different limits.	Multiple layers by category.	Each layer receives Type, Day limit, Night limit and Height in the table.
You want to compare day and night compliance.	Multiple layers by category + change Limit criterion.	Run Daytime and Night-time to compare status. The physical level is identical; only the applied limit changes.
You have settlement polygons and isolated points.	Prefer representative points; otherwise use multiple layers.	The module evaluates polygon centroids. If the edge or facade matters, create specific points.
One layer contains your own limit/height fields.	Use a single layer if all share a criterion, or prepare layers by category.	The current UI does not automatically map arbitrary fields; in multi-layer mode it normalises them to grp_lim_d, grp_lim_n and grp_h_m.

Internal interpretation. When multiple layers are enabled, the plugin creates a temporary normalised point layer. Each feature receives grp_type, grp_h_m, grp_lim_d, grp_lim_n, grp_lim_c and grp_src. The calculation then works with one normalised receiver list.



13. Practical receiver-layer examples

Example A · simple single layer

Layer: receptores_viviendas.gpkg
Geometry: Point
CRS: EPSG:25830
Fields:
 rec_id Integer
 name Text
 type Text
Plugin:
 Receiver layer = receptores_viviendas
 Receiver height = 4.0 m
 Receiver limit = 45.0 dB(A)

Result. All points use the same height and limit. The rec_id, name and type fields are preserved in Noise - Receivers.

Example B · categories

Layer	Type	Day	Night	Height
dwellings	residential	45	40	4.0
farms	farm	50	45	4.0
industrial	industrial	55	50	4.0
sensitive points	sensitive	40	35	4.0

Result. The module internally creates a normalised point layer. Each receiver retains its category and applied limit in rec_type, limit_dba, limit_src, limit_scn and limit_fld.

13b. Receiver examples: case not recommended

Closing the practical examples with the pattern that should be avoided.

Not recommended. Using one very large settlement polygon and expecting the entire boundary to be evaluated. The module evaluates the centroid. To study facades or edges, generate points along the boundary or representative sensitive points.

Remember: `rec_id`, `name` and `type` fields are always preserved in the Noise - Receivers layer, both in single-layer and category mode, which makes it easier to identify each result in reports and audits.



14. DEM/DSM: required format and how it enters the calculation

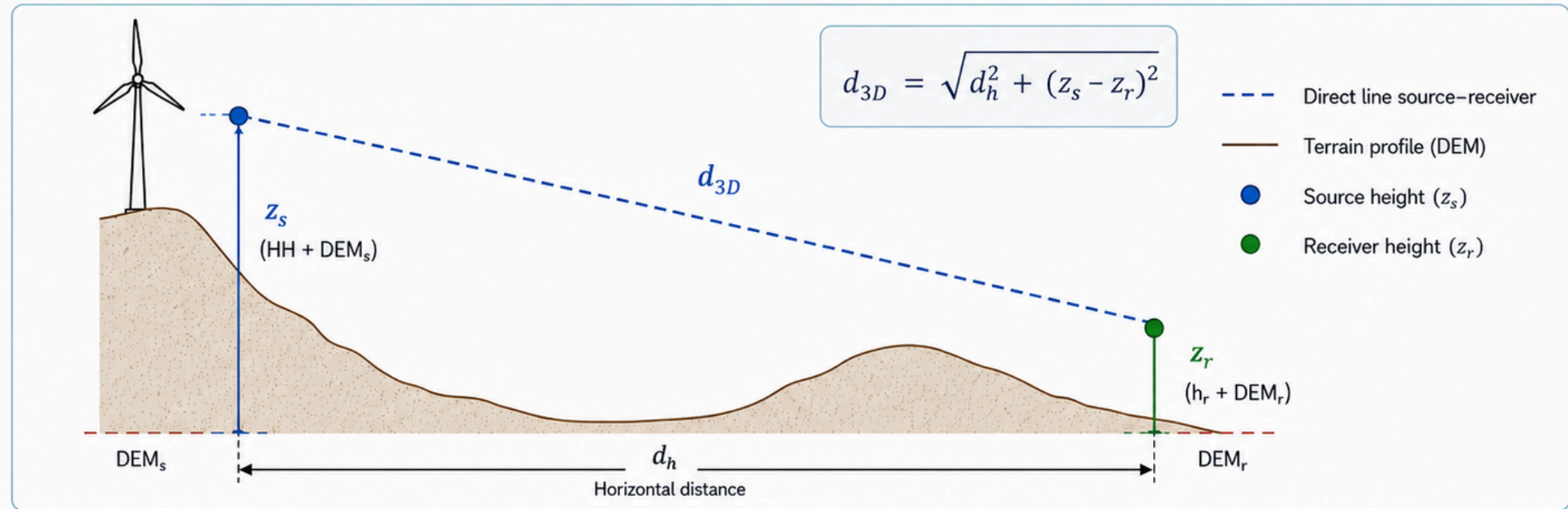
The DEM/DSM does not change turbine emission. It changes propagation geometry: source and receiver elevations, 3D distance and possible topographic screening in the ISO engine.

Input	Format	Use in calculation
DEM/DSM raster	Raster layer loaded in QGIS, same CRS as the project.	Samples ground elevation beneath turbines and receivers.
Resolution	Preferably consistent with the study. The plugin adapts profile spacing to the raster.	Source-receiver topographic profile used to identify the dominant obstacle.
NoData / outside extent	NoData is not converted to elevation 0 for Abar.	If the source or receiver has no valid DEM, Abar is rejected as no_profile.
Source height	$z_s = \text{DEM below turbine} + \text{HH}$.	Affects 3D distance and line of sight.
Receiver height	$z_r = \text{DEM below receiver} + \text{receiver height}$.	Affects 3D distance, line of sight and output <code>rec_ac_z_m</code> .

DTM vs DSM. The control accepts DEM/DSM because QGIS handles both as elevation rasters. For screening noise studies, document whether bare-earth terrain (DTM) or a surface including objects (DSM) is used, because profiles and screening may change.

B2 visual. Source-receiver geometry (3D)

This page shows the key geometric quantities used to describe the acoustic path between a turbine source and a receptor over terrain.



Where:

HH	=	Hub height (centre of the turbine rotor)	[m]	DEM _r	=	Terrain elevation at receiver location	[m]
h_r	=	Receiver evaluation height	[m]	d_h	=	Horizontal distance (plan view)	[m]
DEM _s	=	Terrain elevation at source location	[m]	d_{3D}	=	3D acoustic distance (line-of-sight)	[m]



All heights are above mean sea level (DEM + structure height).



15. Land use and ground factor G

G represents the acoustic character of the ground: 0 = hard/reflective; 1 = soft/porous. With land use, the plugin calculates an effective G for each source-receiver path.

Requirement	Detail
Geometry	Polygon vector layer. Not points, lines or raster.
CRS	Same CRS as the project. If it differs, the calculation stops.
Preferred numeric field	g_factor, g, ground_g, g_value or G. The first finite value is clipped to [0,1].
Alternative text fields	uso_suelo, uso, clase, landuse, cover or type.
Keywords -> G=0	urb, asphalt, roca, duro, edif, industrial.
Keywords -> G=0.5	mixto, mosaico, semi.
Keywords -> G=1	cult, agr, prado, past, forest, veg, poroso, suelo.
Fallback	If there is no intersection or the class is not recognised, use the global/manual G.

How the plugin weights it. For each source-receiver pair, it intersects the line with the polygons and calculates $G_{eff} = \sum(G_i \cdot length_i) / \sum(length_i)$. If no polygon is intersected, it tests the midpoint; if that also fails, it uses the global G.



16. How the land-use layer is read for G

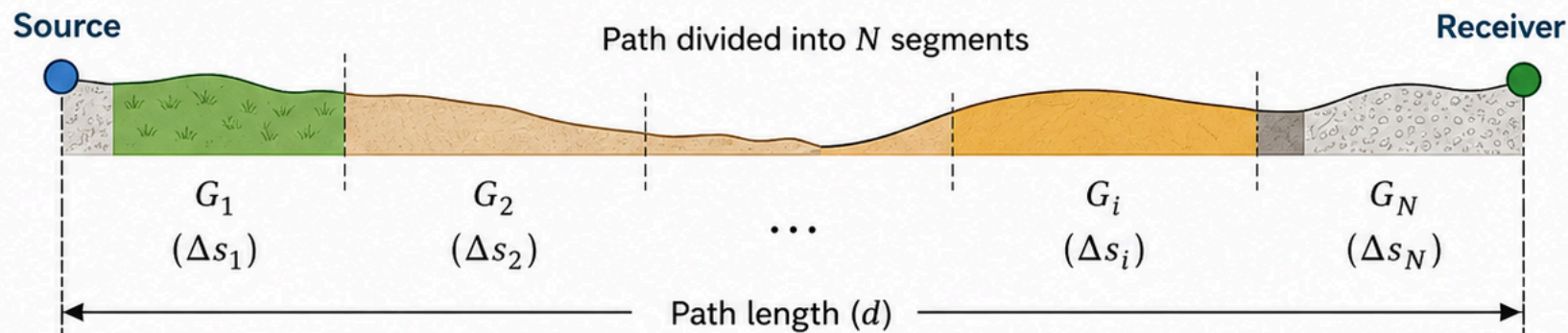
This page explains the mechanism step by step so that it remains traceable in a consultancy guide.

Internal step	Plugin reading	Practical consequence
1. Activation	The layer is only used when Ground mode = From land-use layer and a layer is selected.	If the mode is Global, manual G is used even when the layer is loaded.
2. Layer type	The drop-down lists only polygon vector layers that are not noise outputs.	The layer must be polygonal. A land-cover raster or point layer cannot be used directly.
3. Numeric value	Looks for g_factor, g, ground_g, g_value or G. The first finite value is clipped to 0-1.	A numeric field is the most robust and takes precedence over text.
4. Text class	If no numeric value exists, looks for uso_suelo, uso, clase, landuse, cover or type and applies keywords.	Useful for simple layers, but the equivalences should be documented.
5. Intersection	Intersects the source-receiver line with polygons and weights each G by segment length.	A path can cross several ground uses: it does not use only the receiver or only the turbine.
6. Fallback	If there is no intersection, tests the midpoint. If no polygon is found, uses global G.	Global G is a backup value and remains available when land use is enabled.

Output audit. To verify that the layer is being used, inspect ground_md and ground_g in Noise - Receivers. If ground_g always matches the global value, review ground mode, polygon coverage, CRS and field names.

4. Ground effect and effective G (G_{eff})

From land cover to the path-average factor



Effective ground factor:

$$G_{eff} = \frac{\sum_{i=1}^N G_i \cdot \Delta s_i}{\sum_{i=1}^N \Delta s_i}$$

Typical G values

Surface type	G
Hard (water, concrete, asphalt)	0.0
Mixed (grass, low vegetation)	0.5 – 0.7
Soft (cultivated land, pastures)	1.0



Fixed G (user)

Same G for the whole path



Land-use map

G from reclassified land cover



Effective G_{eff}

Weighted average along the path

G affects mainly the total level through the A_{gr} term.



17. Example of a compatible land-use layer

The supplied test layer is a good format example because it combines a numeric `g_factor` field with a text `uso_suelo` label.

Property	Value
File	uso_suelo_prueba_ruido_subdividido.gpkg
Layer	uso_suelo_prueba_ruido_subdividido
Geometry	POLYGON
CRS	EPSG:25830
Fields	land_id, uso_suelo, g_factor

id	land use	g_factor	Interpretation
File	uso_suelo_prueba_ruido_subdividido.gpkg		
Layer	uso_suelo_prueba_ruido_subdividido		
Geometry	POLYGON		
CRS	EPSG:25830		
Fields	land_id, uso_suelo, g_factor		

Why it works well. The `g_factor` field takes priority over text. This avoids ambiguity caused by translation or unrecognised classes.

Documentation recommendation. Include a G-class table like this in the guide and explain that users may rely on `g_factor` even when the land-use text uses other names.



17A. Land-use layer: purpose, format and role in the calculation

The land-use layer does not define wind-farm restrictions or replace environmental mapping. In the noise module it translates the terrain crossed by each source-receiver path into a ground factor G , which then participates in ground attenuation A_g and the G_{eff} diagnostic.

Element	Recommendation for the module	Why it matters
Geometry type	Polygon or MultiPolygon. One polygon represents an acoustically homogeneous area.	The calculation needs to know which ground type is crossed by the source-receiver line.
CRS	Same projected/metric CRS as the QGIS project, for example EPSG:25830.	Prevents errors in distance, area, intersection and segment length.
Key field	Numeric <code>g_factor</code> between 0 and 1. This is the most traceable field.	G enters directly into construction of G_{eff} and A_g .
Descriptive field	<code>uso_suelo</code> , <code>landuse</code> , class or textual description.	Supports auditing of the interpretation and explanation in the report.
Coverage	At minimum, cover the corridor between turbines and receivers inside the calculation radius.	Gaps or overlaps reduce traceability and may force use of global G .
Relationship to global G	Without land use, the module uses the configured global G .	The layer changes a single G into a path-dependent G .

Practical rule: for consultancy work, always include `g_factor` even when a text class is also supplied. It is more defensible to state “this polygon has $G=0.85$ ” than to depend only on class names.



17B. How to create the land-use layer in QGIS

The recommended workflow is to create a polygon GeoPackage with a metric CRS and a numeric G field. Prepare it before opening the module or, if it is loaded later, press Refresh so it appears in the land-use drop-down.

Step	Action in QGIS	Expected check
1	Create a new Polygon GeoPackage layer.	The layer appears in the panel with Polygon/MultiPolygon geometry.
2	Assign the project CRS, for example EPSG:25830 if layout and receivers are in UTM 30N.	All layers use metres; do not mix with latitude/longitude.
3	Create fields: integer land_id, text uso_suelo and decimal g_factor.	The attribute table can identify and audit each zone.
4	Digitise polygons covering the area between sources, receivers and maximum evaluation radius.	No relevant gaps remain between turbines and receivers.
5	Fill g_factor from 0 to 1 according to acoustic ground behaviour.	G=0 hard/reflective ground; G=1 soft/porous ground.
6	Run Validate geometries or Fix geometries when errors exist.	No invalid geometries, empty polygons or problematic multipart features.
7	Save, load in QGIS, open Noise, press Refresh and select it in Land-use layer.	Check configuration should not report CRS, geometry or G-field warnings.

Recommended minimum fields

```
land_id,uso_suelo,g_factor
1,urban,0.00
2,industrial,0.15
3,cropland,0.85
4,scrub,0.65
5,forest,1.00
```


17C. Recommended G values and common errors

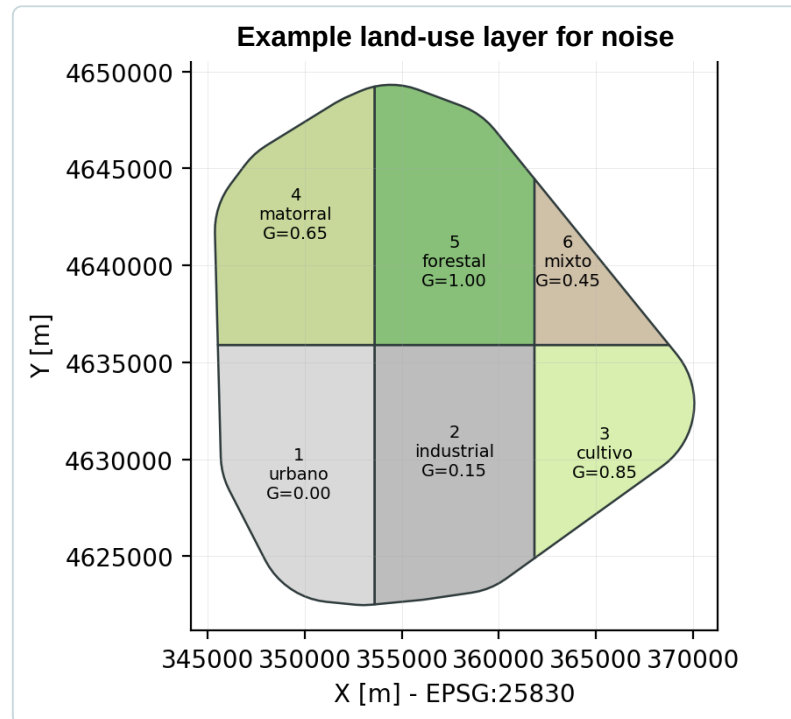
The G factor is an acoustic simplification. It does not seek to classify planning, vegetation or cadastral data with legal precision, but to approximate whether terrain behaves as hard/reflective or soft/porous within the propagation model.

Practical class	Suggested G	Acoustic interpretation	Typical examples
Urban / rock / asphalt / water	0.00	Hard or reflective ground.	Roads, platforms, pavement, water surfaces, bare rock.
Industrial / compacted	0.15	Hard component dominates, with little absorption.	Buildings, compacted yards, industrial areas.
Mixed	0.45	Intermediate behaviour.	Mosaic of tracks, parcels and partially vegetated areas.
Scrub / low vegetation	0.65	Partly soft.	Scrub, irregular grassland, low vegetation.
Cropland / herbaceous	0.85	Mostly soft ground.	Agricultural fields, grassland, unpaved terrain.
Forest / porous	1.00	Soft/porous ground.	Woodland, forest, continuous vegetated cover.

Problem	Calculation symptom	Correction
Different CRS from project	Incoherent G_eff or incorrectly calculated intersections.	Reproject the layer to the project's metric CRS.
Gaps between polygons	Some paths are not well characterised.	Complete coverage or use a conservative global G.
Overlapping classes	One segment can fall into two different land uses.	Dissolve/clip so each area has one dominant class.
g_factor stored as text	The value may not be read as numeric.	Create a real decimal field; use a decimal point.
Values outside 0-1	Agr/G_eff has no physical meaning.	Limit G to the range 0.00-1.00.

17D. Compatible example: uso_suelo_prueba_ruido.gpkg

Layer: uso_suelo_prueba · CRS: EPSG:25830 · Geometry: Polygon · Features: 6.



Minimum attribute table

land_id	uso_suelo	g_factor
1	urbano	0.00
2	industrial	0.15
3	cultivo	0.85
4	matorral	0.65
5	forestal	1.00
6	mixto	0.45

Use in the module. Load the GPKG in QGIS, click Refresh, select the layer under Land-use layer and run Check configuration before Calculate noise.

What this file demonstrates: the layer contains polygons with a text class and an explicit numeric G value. This is the recommended structure for a traceable calculation and for the report to explain where G_{eff} comes from.

The layer does not need to use these exact classes. What matters is that each polygon has a defensible G value and that the calculation area is covered without gaps or relevant overlaps.

18. Calculation parameters with the greatest impact on use

Parameter	Default value / range	What it controls	Common mistake
Maximum radius	5000 m; range 100-50000	Only turbines within the actual horizontal radius are summed.	Radius too small -> receptors with zero or underestimated level.
Map resolution	100 m; range 10-5000	Cell size of the Noise - Map raster.	Excessively fine over large areas -> slow calculation.
Isophones	35,40,45,50 dB(A)	Contours extracted from the raster.	Enabling them without generating the map adds no information.
Alpha attenuation	0.005 dB/m	Fast engine only.	Assuming alpha affects the ISO engine; in ISO it is calculated by band.
Global G	0.5	Manual ground when land-use is not used, or as fallback.	Loading land-use but leaving ground mode set to Global.
T/RH/P	15 °C, 70 %, 101.325 kPa	Band atmospheric absorption in ISO.	Using undocumented conditions in a report.

Recommended activation order. 1) Receptors without raster. 2) Raster at 100-200 m to review the extent. 3) ISO with DEM. 4) Land-use. 5) Fine raster only when the point-receptor case is already coherent.

19. Fast engine vs ISO-aligned

Engine	What it requires	What it calculates	Recommended use
Fast	Global LwA, receptors, radius, global G or land-use, alpha.	Adiv, simplified Aatm, simplified Aground and energy summation.	Iterate many alternatives and detect input errors.
ISO-aligned	Spectrum or template/fallback, T/RH/P, optional DEM and optional land-use.	Octave bands, Adiv, band Aatm, Agr, topographic Abar and A-weighting.	Technical review, traceability and comparison with acoustic tools.

Diagnostic	Where to find it	Interpretation
noise dba	Noise - Receivers	Total receptor level from the energy sum of sources.
max src dba	Noise - Receivers	Contribution from the dominant source, not the total.
dom freq	Noise - Receivers	Dominant band in the ISO engine.
spec src	Noise - Receivers	Origin of the spectrum used: manual, CSV, library, template or fallback.
abar state	Noise - Receivers	Topographic-screening status for the dominant path.
ground g	Noise - Receivers	Effective G used on the dominant path.

20. Module outputs and interpretation of results

The main result is not a single number: it is a set of GIS layers and audit fields that make it possible to review each receptor, each dominant source and the conditions used in the calculation.

Output	What it contains	Purpose
Noise - Receivers	Original receptors with new fields: noise_dba, n_src, limits, margins, dominant-source diagnostics, DEM, G and spectrum.	Main compliance and audit layer.
Noise - Sources	Sources used and contribution statistics.	Check that all selected turbines were included in the calculation.
Noise - Dominant links	Line between each receptor and its dominant source.	Debug distances, critical paths and screening.
Noise - Receivers outside radius	Receptors with no candidate sources inside the radius.	Detect an insufficient radius or misplaced layers.
Noise - Map	Sound-level raster evaluated at cell centres.	Visualise the acoustic footprint.
Noise - Isophones	Equal-level contours generated from the raster.	Communicate the 35/40/45/50 dB(A) zones.

Recommended interpretation. A receptor level is the energy sum of all sources inside the radius. The dominant source, dominant band or dominant Abar are diagnostics: they help explain the result, but they do not replace the total noise_dba.

21. Check configuration and common errors

Symptom	Likely cause	Solution
The layer does not appear in the drop-down list	It was loaded after opening the module, or it is not the expected geometry type.	Click Refresh. Check that receptors are points/polygons and land-use layers are polygons.
CRS error	Receptors, DEM, land-use or layout do not match the project CRS.	Reproject the layers before calculating. Changing only the display CRS is not enough.
All receptors have level 0	Maximum radius too small, layout far away, lat/lon units or sources not selected.	Increase the radius, review the CRS, select the sources and check distances.
Abar does not appear although a DEM is loaded	Source/receptor outside the raster or NoData at the endpoints.	Review DEM extent and NoData values.
Land-use does not change G	Ground mode is still Global, or the layer does not intersect the paths.	Select From land-use layer and review coverage/CRS.
LwA does not match the table	An unnormalised absolute OEM spectrum changes the operating LwA to the A-weighted sum.	Enable Normalize if you need to preserve the global LwA.

Useful sentence for the guide. After any layer change, click Refresh. After any important parameter change, run Check configuration. Calculate only when the configuration summary is coherent.

22. Input checklist before calculation

Check	Question
CRS	Are the project, layout, receptors, DEM and land-use in the same metric CRS?
Layout	Are all turbine layers that should contribute to noise selected?
Source groups	Does each group have the correct LwA, curve or spectrum? Are HH and D coherent?
Receptors	Does the layer use representative points? For polygons, do you accept centroid evaluation?
Limits	Simple mode: correct global limit? Category mode: day/night/height reviewed for each layer?
Radius	Does the maximum radius cover all turbines that may be relevant?
DEM	Does the raster cover sources and receptors? Is it documented as a DTM or DSM?
Land-use	Is the layer polygonal and does it contain g_factor between 0 and 1, or recognisable text classes?
Map	Is the raster resolution reasonable for the area?
Configuration	Was Check configuration completed without errors before Calculate noise?

Recommended guide version v119. Use this v119 as a replacement for the input pages in v115/v116/v117. It retains the receptor workflow and adds a final calculation section with equations formatted for consultancy use.

23. Operational summary of the input chapter

This page replaces the previous internal note and provides a useful conclusion to the input section.

- The only inputs strictly required for a basic calculation are a turbine layout and a receptor layer.
- The receptor should preferably be a point. When polygons are used, the module evaluates their centroid.
- Always click Refresh after loading new layers or modifying existing ones.
- DEM/DSM, land-use, an acoustic curve and an OEM spectrum are optional, but improve traceability and physical realism.
- Before calculating, run Check configuration to validate the CRS, layers and parameters.

Key idea. The guide should make clear that the module is easy to start with limited data, and that extra complexity (G_eff, Abar, OEM spectrum and multiple scenarios) is added only after the base case has been validated.

B1. Complete input map and origin of each parameter

This page summarises the practical approach: it shows not only which input is loaded, but also where every value entering the equations comes from.

Input / parameter	Origin in the plugin or GIS	Use in the calculation	Audit field
x_s, y_s	Turbine-layout geometry or imported CSV.	Distance, radius filter, source-receptor line, G_eff and DEM profile.	src_id, src_layer, dom_src_lyr
HH / hub_h_m	Model or source group in the acoustic table.	$z_s = z_{\text{ground},s} + \text{HH}$; 3D distance and line of sight.	hub_h_m, src_ac_z_m
Operating LWA	Fixed LWA, LWA(ws) curve or absolute OEM spectrum.	Sound power propagated in fast mode or distributed by bands in ISO.	src_lwa, spec_src
x_r, y_r	Receptor point, centroid or raster-cell centre.	Point at which total LpA is evaluated.	rec_id, eval_mode
h_r / rec_h_m	Global UI height or category table.	$z_r = z_{\text{ground},r} + h_r$; 3D distance and line of sight.	rec_h_m, rec_ac_z_m
Maximum radius	Maximum radius [m] in the UI.	Selects candidate sources using the spatial index and actual distance.	covered, outside_radius
G / G_eff	Global G or land-use layer.	Aground/Agr along the path.	ground_g, ground_md
T, RH, P	Atmospheric conditions in the UI.	Band alpha correction for ISO Aatm.	aatm_db
DEM/DSM	Elevation raster loaded in QGIS.	Elevations, topographic profile and Abar.	src_z_m, rec_z_m, abar_state
Limit dB(A)	Global value or day/night/custom category table.	Compliance: margin_db, exceeds and state.	limit_dba, limit_src, limit_scn, limit_fld

Traceability rule: if a number appears in an equation, it must be traceable to a layer, a UI control, a CSV, the DEM/DSM, the land-use layer or a documented internal value.

B2. Acoustic inputs: fixed LwA, curve and OEM spectrum

Priority chain for operating LwA

1. If the group uses Fixed LwA, that value is propagated directly.
2. When it uses Acoustic curve, LwA(ws) is calculated by interpolation or worst case.
3. When an absolute OEM spectrum is loaded without normalisation, the group operating LwA is obtained from the A-weighted sum of the spectrum.
4. When Normalize spectrum is enabled, only the spectral shape is retained and shifted to reproduce the group LwA.

$$LwA_{oper} = \text{interp}(ws_{eval}; ws_i, LwA_i)$$

$$LwA_{oper} = \max(LwA_i) \text{ when worst case is enabled}$$

Duplicates: when a wind speed appears more than once, the maximum LwA is retained.
Outside the range: the nearest endpoint is used, with no extrapolation.

CSV	Minimum format	Reading rules
LwA(ws) curve	wind speed,lwa · 6,101.5 · 7,103.0	First two numeric columns. Separators: comma, semicolon, tab or space. Decimal comma accepted.
Lw spectrum	freq hz,Lw dB · 63,92 · 125,96?	Bands 63?8000 Hz. Absolute unweighted Lw.
LwA spectrum	freq hz,LwA dB	Converted to Lw,b by subtracting A-weighting A_b, avoiding a double application of A-weighting.
Relative shape	freq hz,Lw dB rel	Normalised to the group LwA. Values with a dB(A) header below 20 dB are rejected as inconsistent.

Spectral-shape normalisation

$$Lw,b = LwA + S_b + \Delta, \text{ with } \Delta \text{ adjusted so that } 10 \log_{10}(\sum_b 10^{((Lw,b + A_b)/10)}) = LwA$$

B3. Spectrum priority and spec_src traceability

The ISO engine always requires a band spectrum. If the user does not provide one, the plugin searches for or generates one and records its origin.

Order	Spectrum source	How it is interpreted	Traceability
1	Manual values in the editor	Eight band values; if they appear relative, they are normalised to LwA.	Manual (interface)
2	Group OEM CSV	Absolute values are used directly; relative values are normalised.	CSV: file
3	Spectrum library	.csv/.txt file whose name matches the manufacturer/family.	Library: file
4	Model template	Internal shapes for recognised families: Vestas, Siemens, Nordex, etc.	Template: name
5	Generic fallback	generic large, generic small or generic modern generated from LwA.	Fallback: generated from LwA

Why spec_src matters. When two calculations produce different results, spec_src is the first field to review. It reveals whether the group used an absolute OEM spectrum, a normalised shape, a template or a fallback.

Recommended audit

1. Check fixed LwA/curve.
2. Check whether Normalize spectrum is enabled.
3. Review spec_src in Noise - Receivers.
4. Confirm the dominant band dom_freq when the result depends strongly on Aatm/Abar.

B4. Receptors: modes, layers and fields that are actually read

Be explicit here: the plugin does not interpret every arbitrary field in the receptor layer. The fields read depend on the selected mode.

Mode	User input	Fields used by the plugin	Recommendation
Simple single layer	One layer in Receiver layer; multiple-layers checkbox disabled.	Does not read height/limit fields from the layer. Uses global height and global limit.	For initial screening and receptors sharing the same criterion.
Single layer with attributes	Fields such as name, type, municipality and notes.	Retained as context, but do not change the physics or limit unless mapped by the plugin workflow.	Use for identification, not to assume automatic limits.
Multiple category layers	Checkbox enabled; Add receiver layer; type, day/night/custom limit and height in the table.	Internally normalised to grp_type, grp_h_m, grp_lim_d, grp_lim_n, grp_lim_c and grp_src.	For homes, farms, industrial, sensitive receptors, etc. with different limits.
Polygons/lines	Non-point layer.	Evaluates the centroid as the receptor point.	Create façade/edge points when the centroid does not represent exposure.

Limit criterion: Manual/global, Daytime or Night-time does not change propagation. It only selects the limit compared with noise_dba. limit_dba, margin_db, exceeds and state change; noise_dba does not.

B5. Calculation geometry and candidate-source selection

Variable	Origin	Formula / use
d_xy	Source and receptor coordinates.	$d_{xy} = \sqrt{(x_s - x_r)^2 + (y_s - y_r)^2}$. Compared with Maximum radius.
z_s	DEM beneath turbine + hub height.	$z_s = z_{ground,s} + HH$. Without valid DEM, documented flat-ground/fallback is used.
z_r	DEM beneath receptor + receptor height.	$z_r = z_{ground,r} + h_r$.
d_3D	d_xy and elevation difference.	$d_{3D} = \sqrt{\max(d_{min}^2, d_{xy}^2 + (z_s - z_r)^2)}$.
d_min	Internal safety parameter.	Prevents log(0) and unrealistic paths. The implementation uses 25 m.
covered	Number of sources inside the radius.	When covered = 0, the receptor is placed in the outside-radius layer with level 0.

Spatial index. Sources are indexed in QgsSpatialIndex. For each receptor, a square box of $\pm$ radius is queried first, after which the actual distance is confirmed. The box is only a pre-filter.

Evaluated points. Point receptor: original geometry. Polygon/line: centroid. Raster: cell centre. The model evaluates a finite list of points, not a continuous area.

B6. DEM/DSM: sampling, NoData and Abar states

The DEM/DSM does not change the emitted LwA; it changes the geometry: elevations, 3D distance, line of sight and possible topographic screening.

DEM/DTM element	Implemented rule	Associated output
Endpoints	Sampled beneath source and receptor. If either endpoint has no valid DEM, Abar is not calculated.	src_z_m, rec_z_m, no_profile
Sentinels and NoData	Rejects -9999, -32768, 32767, 32768, 99999, z > 100000 m and provider NoData ranges.	mdt_valid_points, mdt_invalid_points
Source-receptor profile	Samples the full line at a regular step close to raster resolution, practical minimum 5 m; when resolution is unavailable, 10 m.	mdt_sample_step_m, mdt_num_points
Number of points	ceil(d/step)+1, bounded between 50 and 1200 for point receptors.	mdt_num_points
Internal NoData	Intermediate gaps are omitted; they are not converted to elevation 0, avoiding false barriers.	mdt_invalid_points
Noise raster	DEM is pre-sampled for each cell; when a cell fails, z_ground=0 may be used as a documented fallback.	grid diagnostics

abar_state	Meaning
no_dem	No active DEM/DSM is available for screening calculation.
no_profile	A valid profile could not be built, normally because endpoints are outside the raster or NoData.
los_clear	No dominant obstacle rises above the line of sight.
below_threshold	Candidate terrain exists, but does not exceed the activation threshold.
active	Abar is applied using the dominant obstacle and simplified Fresnel diffraction.

B7. Land-use/G: complete reading logic and relationship with Agr

This page explains the complete land-use/G logic and its relationship with Agr in the calculation.

Priority	Field / rule	Result
1. Numeric field	g_factor, g, ground_g, g_value, G	First finite value. Clipped to [0,1]. Overrides any text.
2. Text	uso_suelo, uso, clase, landuse, cover, type	Substring keywords: urbano/duro -> 0; mixto -> 0.5; cultivo/vegetación -> 1.
3. Linear intersection	Source-receptor line clipped by polygons.	Each segment contributes G_i weighted by its length L_i .
4. Midpoint	When no polygon intersects the line.	Searches for the polygon containing the midpoint.
5. Global fallback	When no polygon or valid attribute is available.	Uses the global Ground factor G from the interface.

$$G_{eff} = \sum_i (G_i \cdot L_i) / \sum_i L_i$$

For receptors using the ISO engine, G is calculated along each path. The fast engine uses global G as a screening approximation. In raster mode, land-use can force a slower route because QGIS intersections are not vectorised in the same way.

Audit: when the ground effect seems incorrect, check that the layer is polygonal, the CRS matches, g_factor is in the 0-1 range and output fields ground_g and ground_md indicate the expected route.

B8. Fast and ISO-aligned engines: equations and parameters

Fast engine. Uses a single global LwA for each source and does not propagate bands. Intended for screening and input-error detection.

ISO-aligned engine. Propagates eight octave bands and performs the final energy sum with A-weighting. Aatm depends on T/RH/P; Agr uses G_eff; Abar uses DEM/DTM when available.

$$A_{div} = 20 \log_{10}(d_{3D}) + 11$$

$$L_{p,b} = L_{w,b} - A_{div} - A_{atm,b} - A_{gr,b} - A_{bar,b}$$

$$A_{atm} = \alpha \cdot d_{3D}$$

$$L_{pA} = 10 \log_{10}(\sum_b 10^{(L_{p,b} + A_b)/10})$$

$$b = 63, 125, 250, 500, 1000, 2000, 4000, 8000 \text{ Hz}$$

$$A_{ground} = \text{clamp}(G \cdot 3 \log_{10}(1 + d_{xy}/100) / (1 + (H_s + h_r)/80), 0, 6)$$

$$L_{pA} = L_{wA} - A_{div} - A_{atm} - A_{ground}$$

Correct interpretation: ISO-aligned does not mean a complete certified ISO calculation. The structure follows ISO 9613-2 terms, with documented simplifications: tabulated Aatm with corrections, no Cmet, Dc = 0, simplified Agr and dominant-obstacle Abar.

B9. Aatm, Agr and Abar: parameters used by each term

Term	Parameters used	Origin of the parameters	Implementation notes
Adiv	d_3D	Coordinates, heights, DEM/DSM and minimum distance.	$20 \log_{10}(d) + 11$. Same basis in fast and ISO.
Fast Aatm	alpha, d_3D	alpha in the UI and 3D distance.	Linear, without bands or meteorology.
ISO Aatm	freq, T, RH, P, d_3D	Octave bands and atmospheric conditions from the UI.	Uses alpha at 15 °C / 70 % / 101.325 kPa with simplified corrections.
Fast Agr	Global G, d_xy, HH, h_r	UI and source group/receptor.	Empirical, limited to 6 dB.
ISO Agr	freq, d_xy, HH, h_r, G_eff	Bands, geometry and land-use/global G.	Source, middle and receiver regions; limited to reasonable values.
Abar	DEM/DSM, profile, obstacle, freq, d1, d2	DEM raster and source-receptor geometry.	Simplified Fresnel diffraction for one dominant obstacle; maximum 20 dB.

ISO Aatm

$$A_{atm,b} = \alpha(f, T, RH, P) \cdot d_{3D}$$

alpha is obtained from a band table and corrected for temperature, humidity and pressure. It is not the complete analytical formulation of ISO 9613-1.

Fresnel Abar

$$\delta = (h_{obs}^2/2)(1/d_1 + 1/d_2)$$

$$C = 2f\delta / c$$

Abar is obtained from piecewise ranges of C and limited to 0-20 dB.

B10. Energy summation and dominant diagnostics

A receptor result is not an arithmetic average. The contribution of each source is calculated first, and the contributions are then summed energetically.

By source and band. In the ISO engine, each source produces $L_{p,b}$. A-weighting is applied and the bands are summed to obtain the source L_{pA} .

Total at receptor. The total level combines every source inside the maximum evaluation radius.

$$noise_{dba,r} = 10 \log_{10} (\sum_{s \in R(r)} 10^{L_{pA,s,r}/10})$$

$$L_{pA,s,r} = 10 \log_{10} (\sum_b 10^{(L_{p,b,s,r} + A_b)/10})$$

Diagnostic	Meaning	Interpretation caution
Dominant source	Source with the largest energy contribution at the receptor.	Does not replace the total; it only explains the largest share.
Dominant band dom_freq	Band with the largest A-weighted contribution in the dominant source.	May change with spectrum, Aatm or Abar.
abar_max_db / maxab_*	Path with the greatest Abar among contributing sources.	May not be the energetically dominant source.
abar_ew_db	Abar weighted by contribution energy.	More representative of the total screening effect than an isolated maximum.
abar_screen_n	Number of paths with significant or active Abar.	Uses a small threshold to count genuine screens.

B11. GIS audit fields: what to review when something does not match

Audit question	Field(s) to review	Practical interpretation
Is the receptor inside the radius?	covered	0 means no candidate sources; review radius/CRS.
Which source dominates the level?	src_id, max_src, dom_src_lyr, lp_dom_db	Identifies the turbine/layer with the largest weight in noise_dba.
Where did the spectrum come from?	spec_src, dom_freq, src_lwa	Distinguishes absolute OEM, normalised, template or fallback.
Was land-use used?	ground_g, ground_md	ground_g shows effective G; ground_md indicates global/land-use.
Was the DEM used correctly?	src_z_m, rec_z_m, src_ac_z_m, rec_ac_z_m	Ground and acoustic elevations used for line of sight.
Is there screening?	abar_state, abar_db, obs_h_m, obs_d1_m, obs_d2_m	Status and dominant-obstacle parameters for the dominant source.
Is another source more heavily screened?	maxab_src, maxab_state, maxab_obs_h, maxab_d1, maxab_d2	Isolates DTM problems even when that source is not energetically dominant.
Does it comply with the limit?	limit_dba, margin_db, exceeds, state	state = exceeds, near limit or compliant.

Recommended debugging order: 1) CRS and units, 2) sources inside radius, 3) LwA/spec_src, 4) receptor height and limit, 5) DEM/NoData, 6) ground_g/ground_md, 7) abar_state/maxab, 8) raster/resolution when applicable.

B12. Consultancy checklist and physical limitations of the model

Section	Checklist before delivering results
QGIS project	Consistent metric CRS; no mixed lat/lon layers; distances and units reviewed.
Sources	Correct layout; acoustic groups reviewed; HH and LwA/curve/spectrum documented.
Receptors	Representative points; centroid use documented for polygons; category layers used when limits differ.
Scenarios	Separate acoustic scenario, spectrum and limit criterion; do not confuse a limit change with a change in noise_dba.
DEM/DSM	Correct CRS; NoData reviewed; DTM vs DSM documented; coherent abar_state.
Land-use/G	Polygon layer; g_factor 0-1; area coverage; ground_g/ground_md audited.
Outputs	Review noise_dba, margin_db, state, spec_src, ground_g, abar_state and maxab_* for critical receptors.

Declared limitation	How to explain it
Technical screening	Does not replace a regulatory acoustic study or external validation when required by the permitting process.
ISO-aligned	ISO 9613-2 structure, with documented simplifications.
No Cmet	No long-term meteorological correction is applied.
Dc = 0	Source directivity is not modelled.
Simplified Abar	Diffraction over one dominant obstacle, with no lateral diffraction or multiple barriers.
Octave bands	Eight bands from 63 to 8000 Hz, not one-third-octave bands.

Final message for the guide: VelantisWind is suitable for screening, comparison of alternatives and traceable input preparation. The strength of the guide should be to explain what is calculated, which data are used, what is simplified and how each GIS result can be audited.



B1. Physical source-receptor workflow

The calculation can be followed from each acoustic source to each receptor and finally to the compliance status. The sequence below links each physical stage to the corresponding inputs and audit fields.

Step	What it calculates	Main input	Output / audit
1. Selection	Sources inside the calculation radius	Layout, CRS, Rmax	covered, n_src
2. Geometry	Distances and acoustic elevations	X/Y, HH, receiver height, DEM	dist_m, dist3d_m, src_z_m, rec_z_m
3. Propagation	Distance, atmospheric, ground and barrier losses	Engine, atmosphere, G, DEM	adiv_db, aatm_db, ground_db, abar_db
4. Summation	Energy sum by source and receiver	Lp from each source	noise_dba, max_src_dba
5. Compliance	Comparison with the limit	limit_dba	margin_db, state

$$S_r = \{ s : d_{xy}(s,r) \leq R_{max} \}$$

Set of candidate sources associated with receiver r.

$$E_r = \sum_{s \in S_r} 10^{(L_{pA,s,r} / 10)} \quad ; \quad L_{pA,r} = 10 \log_{10}(E_r)$$

Energy summation of source contributions. Decibels are not added arithmetically.

Practical reading: differences in the final level can be traced back to source selection, geometry, propagation terms or energy summation.

B2. 3D geometry: elevations, distance and DEM/DTM

The DEM/DTM does not modify turbine sound power. It modifies the acoustic elevations and 3D distance and enables evaluation of topographic screening.

$$z_{s,ac} = z_{DEM}(x_s, y_s) + H_s \quad ; \quad z_{r,ac} = z_{DEM}(x_r, y_r) + h_r$$

Acoustic elevations of source and receiver.

$$d_{xy} = \sqrt{(x_s - x_r)^2 + (y_s - y_r)^2}$$

Horizontal distance in a metric CRS. Latitude/longitude coordinates must be reprojected before use.

$$d_{3D} = \max(d_{min}, \sqrt{d_{xy}^2 + (z_{s,ac} - z_{r,ac})^2})$$

Distance used for divergence and atmospheric absorption. d_{min} prevents singularities.

Without a valid DEM, the calculation can continue using flat ground or a documented fallback, but Abar loses traceability because no useful topographic profile is available.

B3. Acoustic emission: fixed LwA, curve and OEM spectrum

Emission is defined for each source group. The module can use a fixed LwA, interpolate an LwA(ws) curve or read an OEM octave-band spectrum.

$$L_{wA}(v) = \text{interp}(v ; \{ (v_i, L_{wA,i}) \})$$

LwA(ws) curve: linear interpolation; outside the range, the nearest endpoint is used.

$$E_A = \sum_b 10^{((L_{w,b,s} + A_b)/10)} \quad ; \quad L_{wA,s} = 10 \log_{10}(E_A)$$

For an absolute OEM spectrum without normalisation, operating LwA is obtained from the A-weighted band sum.

$$L_{w,b,s}^{\text{norm}} = L_{w,b,s} + \Delta_A \quad ; \quad \Delta_A = L_{wA,s}^{\text{target}} - L_{wA,s}^{\text{spec}}$$

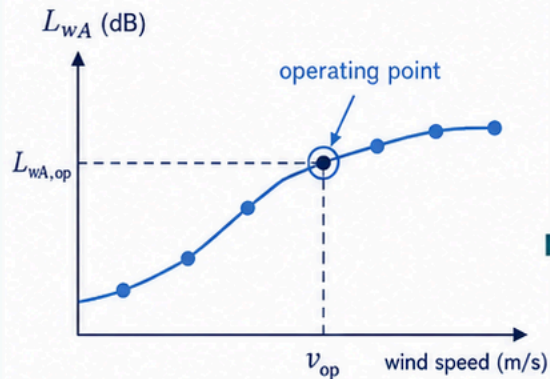
With spectrum normalisation enabled, the spectral shape is retained and shifted to reproduce the target group LwA.

The LwA(ws) curve defines global sound power by wind speed; the spectrum distributes the acoustic energy among octave bands.

B3A. L_{wA} curve and spectrum handling

From wind-speed-dependent sound power to the octave-band spectrum used in propagation.

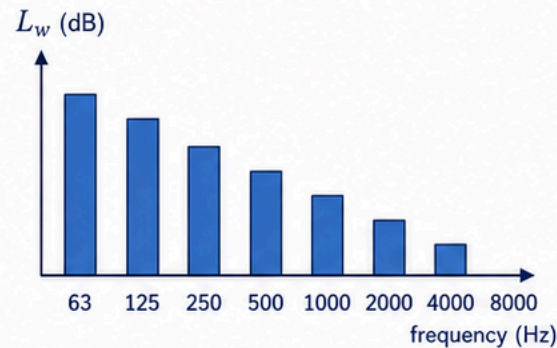
1. $L_{wA}(ws)$ acoustic curve



$$L_{wA}(v) = \text{interp}(v; \{(v_i, L_{wA,i})\})$$

The operating wind speed selects the overall sound power level.

2. OEM spectrum



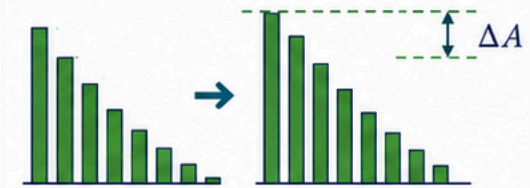
Absolute OEM:
manufacturer values per band



Normalized OEM:
relative spectral shape
(sum = 0 dB)

The spectrum distributes the source energy among bands.

3. Match the target L_{wA}



$$L_{w,b}^{\text{adj}} = L_{w,b}^{\text{norm}} + \Delta A$$

$$\Delta A = L_{wA,\text{target}} - L_{wA,\text{spec}}$$

$$L_{wA} = 10 \log_{10} \sum_b 10^{\frac{L_{w,b} + A_b}{10}}$$

When Normalize spectrum is enabled, the spectral shape is preserved and shifted to match the target L_{wA} .



Key idea: the $L_{wA}(ws)$ curve defines the total sound power, while the OEM spectrum controls how that power is distributed by frequency for propagation calculations.

B4. Fast engine: A-weighted screening

The Fast engine works with a single global A-weighted band. It is useful for debugging inputs and obtaining an initial result, but it does not replace a band-by-band audit.

$$A_{\text{div}} = 20 \log_{10}(d_{\text{3D}}) + 11$$

Geometric-divergence attenuation for each source-receiver pair.

$$A_{\text{tot}} = A_{\text{div}} + \alpha \cdot d_{\text{3D}} + A_{\text{ground}} + A_{\text{bar}}$$

Total attenuation used by the Fast engine.

$$L_{\text{pA},s,r} = L_{\text{wA},s} + D_{\text{c}} - A_{\text{tot}}$$

A-weighted level from one source at one receiver.

Linear attenuation α is a broadband simplification of atmospheric absorption. Use this engine mainly to verify geometry, radius, CRS, receivers and LwA consistency before enabling ISO-aligned.

B5. ISO-aligned engine: band calculation

In the ISO-aligned engine, propagation is calculated in octave bands and recombined in dB(A) using A-weighting and energy summation.

$$L_{p,b} = L_{w,b} + D_c - A_{div} - A_{atm,b} - A_{gr,b} - A_{bar,b}$$

Propagation by octave band and source-receiver pair.

$$E_A = \sum_b 10^{(0.1 \cdot (L_{p,b} + A_b))} \quad ; \quad L_{pA} = 10 \log_{10}(E_A)$$

Conversion of one source contribution to an A-weighted level.

Term	Interpretation
Adiv	Geometric-spreading loss using 3D distance.
Aatm,b	Band atmospheric absorption based on temperature, humidity and pressure.
Agr,b	Ground effect from global G or land-use-derived G_eff.
Abar,b	Topographic screening by a dominant obstacle when supported by the DEM.

The term-by-term decomposition provides a direct route for comparing scenarios and auditing differences against other software.

Visual comparison. Fast engine vs ISO-aligned



Fast engine

Quick screening and input checking.

$$L_{p,A} = L_{w,A} + D_c - A_{div} - \alpha \cdot d$$

Global dB(A) calculation with linear attenuation.



Includes

- Geometric divergence A_{div}
- Linear attenuation $\alpha \cdot d$
- Receiver limit check



Does not explicitly resolve

- Octave-band spectrum
- Atmospheric absorption by frequency
- Ground effect $A_{gr}(f)$
- Detailed barrier screening $A_{bar}(f)$



Best for: first screening, troubleshooting, quick layout checks.



ISO-aligned engine

Detailed technical review with octave-band propagation.

$$L_{p,A} = 10 \log_{10}(\sum_f 10^{(L_{p,f} + A_f)/10})$$

$$L_{p,f} = L_{w,f} + D_c - A_{div} - A_{atm,f} - A_{gr,f} - A_{bar,f}$$

Octave-band ISO 9613-2-aligned propagation and A-weighted recombination.



Includes

- Octave-band propagation
- Atmospheric absorption $A_{atm}(f, T, RH, P)$
- Ground effect $A_{gr}(f) / G_{eff}$
- Barrier screening $A_{bar}(f)$
- DEM / terrain profile usage
- OEM spectrum handling



Best for: defensible studies, comparison with specialist tools, technical review.

Aspect	Fast engine	ISO-aligned
Calculation domain	Global dB(A)	Octave bands + A-weighted sum
Atmosphere	Linear attenuation α	A_{atm} by frequency, T , RH , P
Ground	Global simplified	A_{gr} with G / G_{eff}
Barrier screening	Simplified / limited	A_{bar} from profile-based screening
DEM usage	Optional / limited	Terrain elevations and profile support
OEM spectrum	Not essential	Supported and important
Speed	Faster	Slower but more complete



Practical rule

Start with Fast to validate CRS, layers and acoustic inputs. Move to ISO-aligned when the case is stable and you need a more defensible physical interpretation.

B6. Atmospheric absorption Aatm

Aatm is calculated by band. The expression below identifies the inputs that feed the correction and the distance conversion applied by the module.

$$A_{atm,b} = \alpha_b(T, RH, P) \cdot d_{3D} / 1000$$

Band atmospheric absorption. α_b is expressed in dB/km and d_3D is converted from metres to kilometres.

Input	Unit	Role in the calculation
Temperature	°C	Corrects α_b for each band.
Relative humidity	%	Especially affects the middle and high bands.
Pressure	kPa	Atmospheric reference; default 101.325 kPa.
Bands	63-8000 Hz	Aatm increases with frequency, which is why the spectrum matters.

Limitation: in this implementation, absorption is an approximation aligned with the ISO workflow, not a complete certified reproduction of ISO 9613-1.

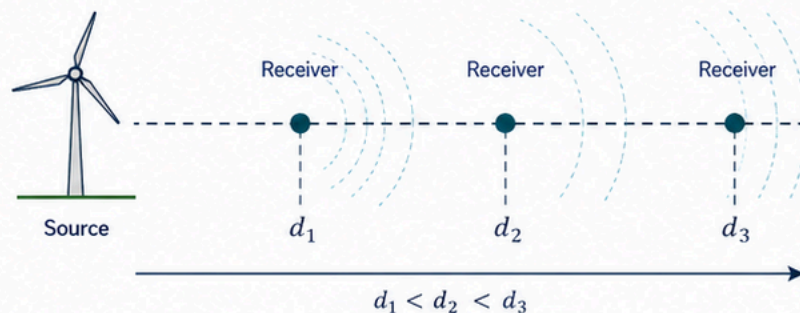
B6A. Distance and atmospheric attenuation

How A_{div} and A_{atm} reduce the sound level along the propagation path.



Geometric divergence (A_{div})

Sound energy spreads out as distance increases.



$$A_{\text{div}} = 20 \log_{10}(d) + 11$$

d in meters. Result in dB.



Key points

- Depends only on propagation distance
- Applied to each source–receiver pair
- In free field, doubling distance reduces level by about 6 dB

Illustrative distance check

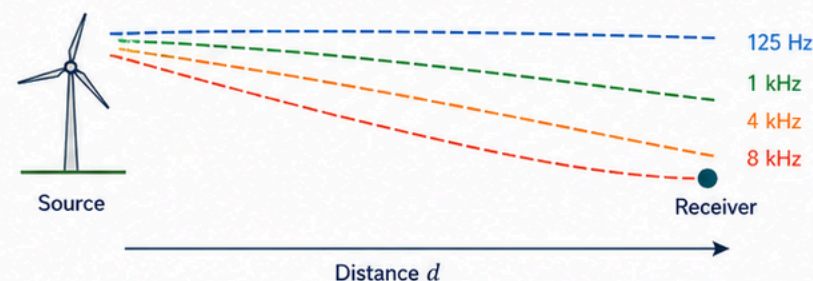
Near	Medium	Far
$d_1 = 500 \text{ m}$	$d_2 = 1000 \text{ m}$	$d_3 = 2000 \text{ m}$
$A_{\text{div}} \approx 65.0 \text{ dB}$	$A_{\text{div}} \approx 71.0 \text{ dB}$	$A_{\text{div}} \approx 77.0 \text{ dB}$

Example only. Values depend on the exact distances.



Atmospheric absorption (A_{atm})

The atmosphere absorbs sound; effect increases with frequency.



$$A_{\text{atm},b} = \alpha_b(T, RH, P) \cdot \frac{d}{1000}$$

$A_{\text{atm},b}$ in dB. d in meters. α_b in dB/km for octave band b .



Inputs

- Temperature (T)
- Relative humidity (RH)
- Pressure (P)
- Distance (d)
- Octave band (b)



Key points

- Absorption is calculated by band
- High frequencies usually attenuate more than low frequencies
- The spectrum therefore matters



Practical reading: A_{div} controls the basic decay with distance. A_{atm} adds frequency-dependent atmospheric losses on top of that decay.



B7. Ground: global G, land use and G_eff

The ground factor can be entered as a global value or supplied through a polygon layer. When land use is available, the module calculates an effective G value for each propagation path.

$$G_{\text{eff}}(s, r) = \sum_i G_i L_i / \sum_i L_i$$

Length-weighted average of the path segment inside each polygon.

$$A_{\text{gr},b} = f_b(G_{\text{eff}}, h_s, h_r, d_{xy})$$

A_{gr} is evaluated by octave band in the ISO-aligned engine.

If no land-use layer exists, or no valid intersection is found, the module uses the selected global G value. The fields ground_g and ground_md make it possible to audit whether the result comes from land use or from the global fallback.



B8. DEM/DTM, line of sight and Abar

Abar summarises the topographic screening obtained from the profile between source and receiver. The model identifies one dominant obstacle and records its parameters.

$$z_LOS(t) = z_s,ac + t (z_r,ac - z_s,ac), \quad 0 \leq t \leq 1$$

Direct line between the acoustic source and the receiver.

$$h_obs = \max_i [z_DEM,i - z_LOS(t_i)]$$

Height of the dominant obstacle above the line of sight.

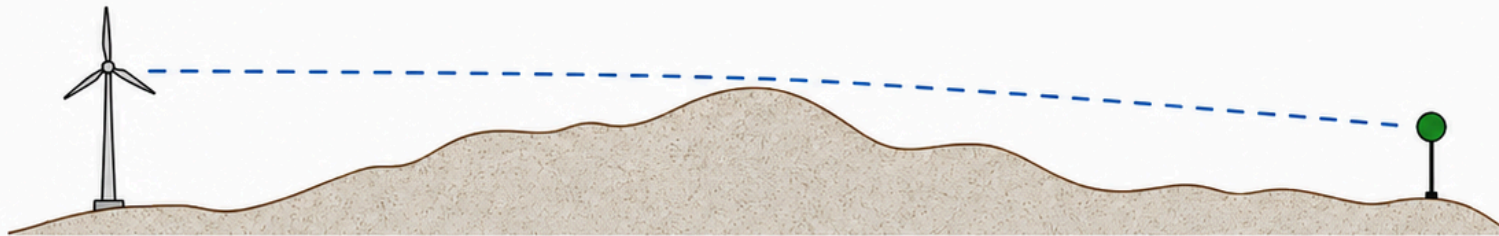
$$A_bar,b = \text{clip}(F(C, \delta_b), 0, 20)$$

Simplified barrier attenuation, bounded to prevent non-physical values.

B8 visual. Terrain profile and screening (A_{bar})

This page explains how the module uses the DEM to evaluate line-of-sight interception and the resulting terrain screening term A_{bar} applied to the propagation path.

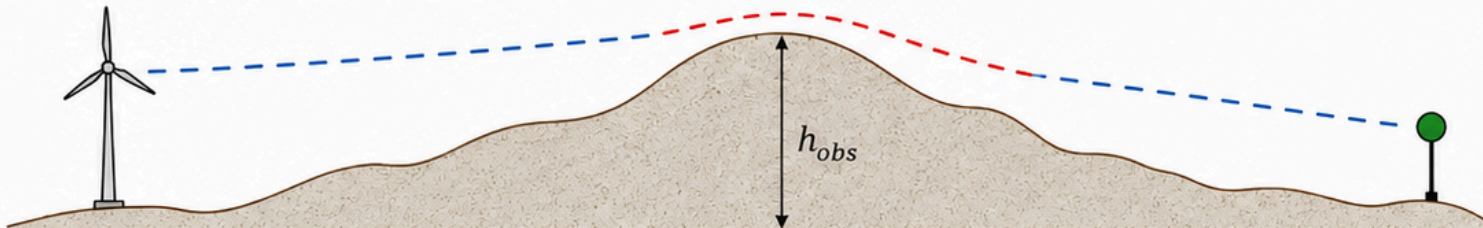
A. Line of sight not blocked



No significant
interception

$$A_{bar} = 0 \text{ dB}$$

B. Line of sight intercepted by terrain



Interception
occurs

$$A_{bar} > 0 \text{ dB}$$

(diffraction)

The DEM is used to:

- ✓ Obtain absolute elevations (z_s , z_r) of source and receiver.
- ✓ Build the source–receiver path profile along the terrain.
- ✓ Detect possible interception by terrain or barriers.
- ✓ Compute A_{bar} when the path is obstructed.



Important

The model does not perform full line-of-sight analysis for every intermediate obstacle.

It uses the ISO 9613-2 screening method based on the path profile to determine A_{bar} .



B9. Simplified Fresnel formulation and barrier parameters

Abar must not be interpreted as a complete multi-barrier diffraction model. The module documents one dominant obstacle.

$$\lambda_b = c / f_b$$

Wavelength for each band.

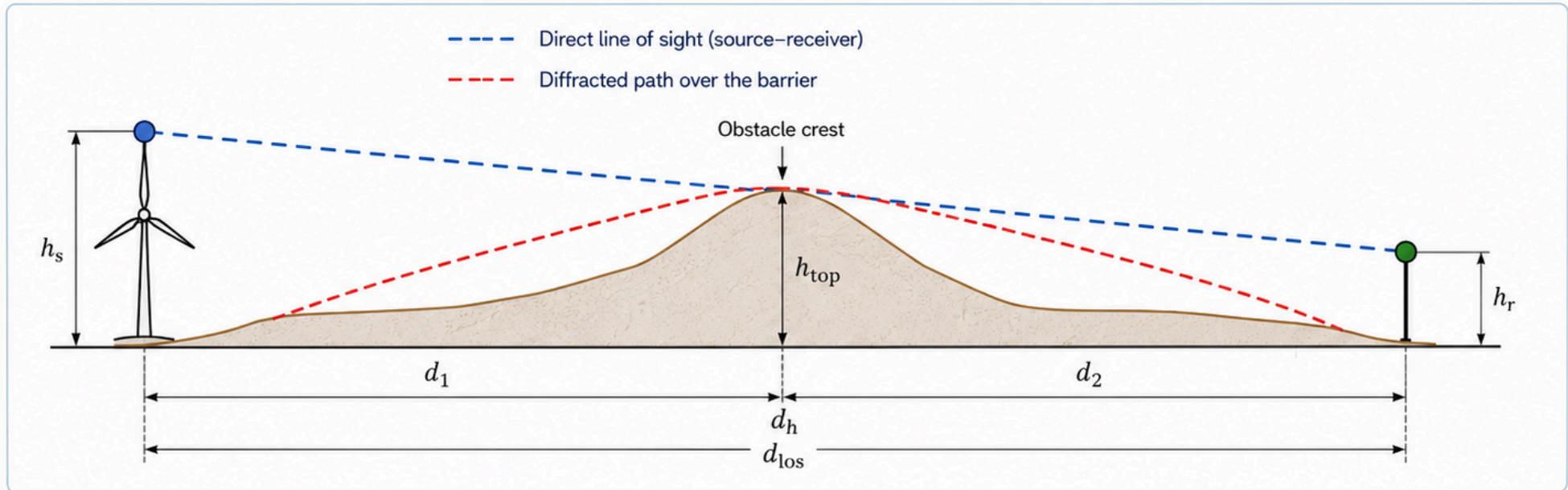
$$F_b = 2\delta / \lambda_b$$

Simplified Fresnel number.

Audit field	What it allows you to review
abar_state	Shows whether Abar is inactive, active or not applicable because no valid profile is available.
abar_db	Barrier attenuation applied to the dominant source.
obs_h_m	Height of the dominant obstacle relative to the line of sight.
obs_d1_m / obs_d2_m	Distances from the source and receiver to the obstacle.
maxab_*	Identifies another, more screened source even when it is not energetically dominant.

B9 visual. Barrier screening (A_{bar})

When sound propagates over terrain, a barrier or ridge can block the direct line of sight and cause diffraction. The attenuation depends on the geometry and the Fresnel number of the diffracted path.



Fresnel number (over the barrier):

$$N = \frac{2 \cdot \delta}{\lambda}$$

Path difference (δ):

$$\delta = (d_1 + d_2) - d_{los}$$

d_{los} : direct line distance

Barrier attenuation (simplified per ISO 9613-2):

$$A_{bar} = \begin{cases} 0 & N \leq -0.78 \\ 10 \log_{10}(3 + 20N) & -0.78 < N < 0 \\ 10 \log_{10}(3 + 20N) + 5.8(N - 0.1) & N \geq 0 \end{cases} \quad [\text{dB}]$$



If no barrier intercepts the path, $A_{bar} = 0$ dB.



B10. Energy summation, compliance and dominant source

The total receiver level is obtained by summing acoustic energy, not decibels. The result is then compared with the limit configured for the receiver or scenario.

$$L_{pA,r} = 10 \log_{10}(\sum_s 10^{(L_{pA,s,r} / 10)})$$

Total A-weighted level at the receiver.

$$\text{margin}_r = L_{pA,r} - \text{limit}_r$$

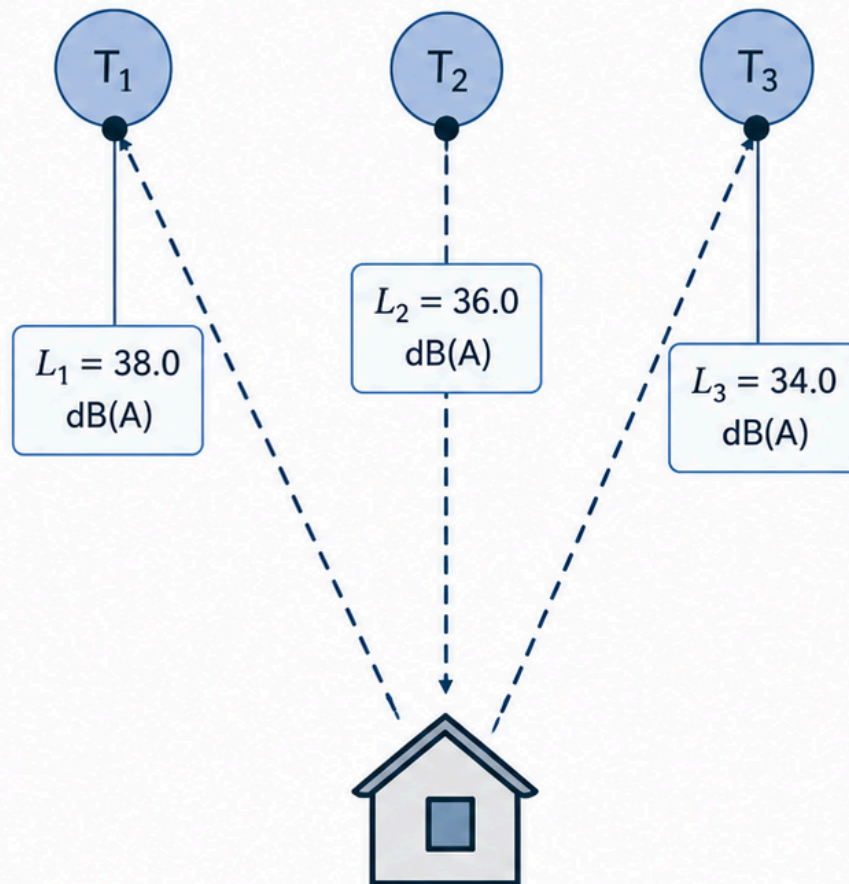
Margin relative to the limit. A positive value means exceedance.

Status	Practical rule
OK	margin_db <= 0
Near limit	The result is close to the configured limit; review input accuracy.
Exceeds	margin_db > 0; review the dominant source, spectrum, DEM, G and the selected limit.

B10 visual. Sum of multiple turbines (energy)

Levels from multiple turbines do not add arithmetically because sound is a form of energy.

The module sums contributions energetically to obtain the total level at the receiver.



Energy sum:

$$L_{\text{tot}} = 10 \log_{10} \left(\sum_{i=1}^n 10^{(L_i/10)} \right)$$

Example:

$$\begin{aligned} L_{\text{tot}} &= 10 \log_{10} \left(10^{(38.0/10)} + 10^{(36.0/10)} + 10^{(34.0/10)} \right) \\ &= 10 \log_{10} \left(10^{3.80} + 10^{3.60} + 10^{3.40} \right) \\ &= 10 \log_{10} (6309 + 3981 + 2512) \\ &= 10 \log_{10} (12802) = 40.2 \text{ dB(A)} \end{aligned}$$

Notes

- ✓ The total level is higher than the highest individual level, but not the arithmetic sum.
- ✓ The module also reports the dominant turbine (highest individual contribution).



B11. Noise raster and isophones

The raster applies the same source-receiver calculation to a grid of virtual receivers. Isophones are extracted as level contours from that raster.

$$\text{cell}_{ij} \equiv r_{ij}, \quad L_{pA,ij} = 10 \log_{10}(E_{ij})$$

Each cell is evaluated as a virtual receiver.

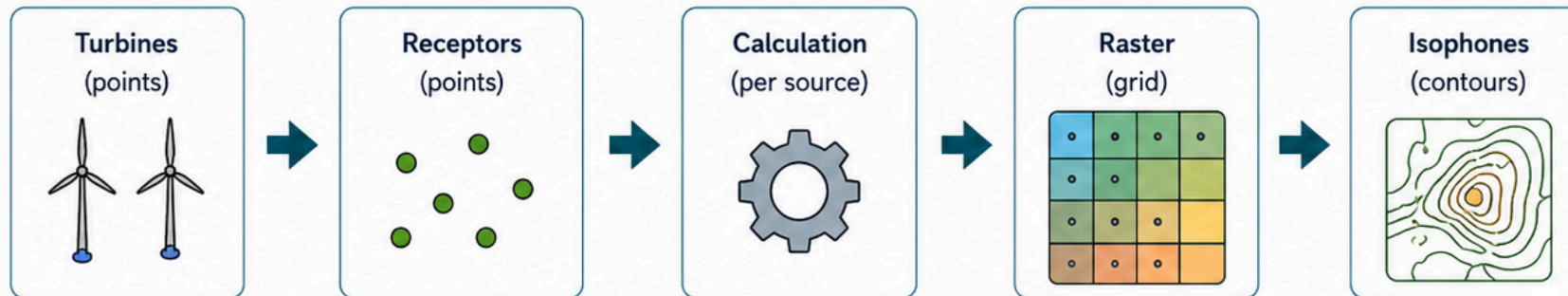
$$\text{Iso}(L) = \{ (x, y) : L_{pA}(x, y) = L \}$$

Isophone curves for levels such as 35, 40, 45 and 50 dB(A).

Map resolution controls processing cost and spatial detail. A very fine raster does not improve physical accuracy when LwA, receiver definitions, DEM or land-use inputs are still preliminary.

B11 visual. From point results to maps and isophones

After calculations at every receptor, the module creates gridded maps and contour lines (isophones) to visualise noise levels across the study area.



Outputs

- ✓ Point results (per receiver)
- ✓ Raster map (dB(A))
- ✓ Isophone contours (e.g. 35, 40, 45, 50 dB(A))
- ✓ Dominant source / contribution
- ✓ Summary tables and statistics

GIS layers and reports

- Noise - Sources
- Noise - Receivers
- Noise - Dominant links
- Receivers outside radius
- HTML / TXT / XLSX reports



These maps are screening outputs for layout assessment and comparison. Final regulatory conclusions require the applicable acoustic study and review process.



B12. Quick map: equation - input - audit field

Use this summary to identify whether a difference in results comes from the input data, geometry, DEM/DTM, ground treatment or the selected limit criterion.

Term	Input that feeds it	GIS field(s) for auditing
LwA / Lw,b	Source group, LwA(ws) curve, OEM spectrum	src_lwa, spec_src, dom_freq
dxy / d3D	CRS, X/Y coordinates, DEM, HH, receiver height	dist_m, dist3d_m, src_z_m, rec_z_m
Adiv	Actual 3D distance and minimum-distance safeguard	adiv_db
Aatm,b	Temperature, humidity, pressure and octave band	aatm_db
G_eff / Agr	Global G or path-based land use	ground_g, ground_md, ground_db
Abar	DEM/DSM, profile and dominant obstacle	abar_state, abar_db, obs_h_m, maxab_*
LpA,r	Energy sum of sources within the radius	noise_dba, n_src, max_src_dba
Compliance	Receiver/scenario limit	limit_dba, margin_db, state

Recommended troubleshooting order: CRS/units -> sources within radius -> LwA/spec_src -> heights -> DEM/NoData -> ground_g/ground_md -> abar_state/maxab -> raster/resolution.



33. Correct interpretation of the physical model

This section separates the general acoustic formulation from the specific approximations implemented in the code, so that users can interpret what is calculated and the simplifications involved.

Term	What it represents	How the module implements it
Lw,b	Source sound power by octave band.	From the OEM spectrum, editor, library, template or fallback based on global LwA.
Dc	Directivity correction.	No directivity is applied: equivalent to Dc = 0 dB.
Adiv	Spherical geometrical divergence.	$20 \log_{10}(d3D) + 11$ with a minimum-distance safeguard.
Aatm	Atmospheric absorption.	Band table with simplified corrections for temperature, humidity and pressure.
Agr	Ground effect.	Fast engine: empirical. ISO engine: source, middle and receiver regions using G_eff.
Abar	Topographic screening.	Dominant DEM/DTM obstacle and Fresnel diffraction. No multiple barriers or lateral diffraction.

Interpretation note. The ISO-aligned engine follows the octave-band propagation structure of ISO 9613-2, but it must not be presented as a complete certified implementation. Aatm, Agr and Abar include documented simplifications.



34. Atmosphere: what Aatm actually calculates

Atmospheric absorption is calculated by octave band, but not with the full analytical formulation of ISO 9613-1. The code uses a base table for 15 °C, 70% RH and 101.325 kPa, then applies simple correction factors.

$$\alpha_b = \alpha_{ref,b} [1 + 0.01(T - 15)] [1 + 0.003(RH - 50)] \cdot 101.325 / P$$

Implemented atmospheric absorption coefficient by band, in dB/m.

$$A_{atm,b} = \alpha_b \cdot d_{3D}$$

Atmospheric attenuation along the source-receiver path for one band.

Band [Hz]	63	125	250	500	1000	2000	4000	8000
α_{ref} [dB/m]	0.0001	0.0003	0.0008	0.0020	0.0040	0.0095	0.0280	0.0900



34b. Interpreting Aatm

Interpretation. Aatm increases with 3D distance and is generally much larger at high frequencies. For sensitive studies, document the T/RH/P values used and avoid stating that the full ISO 9613-1 analytical model has been applied: this is a tabulated approximation with corrections.

Practical effect. For the same source and receiver, moving to a higher frequency band greatly increases Aatm. This is why the OEM spectrum matters: a turbine with more energy at high frequencies may be more strongly attenuated at long range than one dominated by lower frequencies.

How to report it. When the module is used in reports or software comparisons, clearly state the atmospheric conditions and explain that Aatm is based on a reference table by octave band with simplified correction factors.



35. Ground: physical difference between the fast and ISO engines

Ground effect is one of the terms most easily misinterpreted. The fast engine and the ISO engine do not perform the same calculation.

Fast engine

Empirical ground effect. Uses global G; the land-use layer does not modify this engine.

Correct use: rapid, robust screening to identify critical receivers or input errors. Do not use it as an ISO explanation of ground effect.

ISO-aligned engine

Calculates A_{gr} by octave band. Uses G_{eff} when land use is available; otherwise it uses global G.

Current implementation distinguishes source, middle and receiver regions, while the spatial detail of G enters earlier through path-weighted G_{eff} .

$$A_{gr,b} = \text{clamp}(A_s + A_m + A_r, 0, 10)$$

$$A_{ground} = \text{clamp}[G \cdot 3 \log_{10}(1 + d_{xy}/100) / (1 + (H_s + h_r)/80), 0, 6]$$

$$A_s = G_{eff} A_{g,b}(H_s), \quad A_m = G_{eff} A_{g,b}((H_s + h_r)/2), \quad A_r = G_{eff} A_{g,b}(h_r)$$

Important clarification. Although the code calculates d_{source} , $d_{receiver}$ and d_{middle} , those lengths are currently used mainly to determine whether a middle region exists. There is no continuous regional integration of G; spatial variation enters earlier through G_{eff} .



36. Land use and G_eff: precise physical interpretation

The land-use layer is not rasterised or sampled point by point. The module traces the source-receiver line, intersects it with polygons and calculates an average G value weighted by path length.

$$G_{eff} = \frac{\sum_i G_i L_i}{\sum_i L_i}$$

Length-weighted mean of the segments intersected by the source-receiver line.

Priority	How the layer is read	Result
1	Numeric fields: g factor, g, ground g, g value, G.	First finite value, clipped to [0,1].
2	Text fields: uso suelo, uso, clase, landuse, cover, type.	Keywords: urban/hard = 0, mixed = 0.5, crops/grass/forest = 1.
3	Line intersection with polygons.	G_eff = length-weighted mean.
4	No line intersection.	Test the midpoint of the path.
5	No polygon at the midpoint.	Use the global/manual G value.



36b. Auditing G_eff in the results

Review ground_g and ground_md in the outputs. If you expected land use but ground_g always matches the global value, the layer may not intersect the path, may not be polygonal, may use the wrong CRS, or its fields may not be recognised.

Field	Recommended interpretation
ground_g	Effective G used by the dominant source. With land use, it should vary when paths cross different polygons.
ground_md	Declared ground mode: global or landuse.
aground_db	Agr or Aground for the dominant source. It is not a sum over the whole receiver.
path diagnostics	Internal/diagnostic outputs can be used to review each source-receiver pair with its G value, distance and attenuation terms.



37. DEM/DTM and Abar: active, below_threshold and los_clear

Abar is not activated merely because a DEM is loaded. It becomes active only when the source-receiver profile contains an obstacle that rises above the line of sight by more than a conservative threshold.

State	Physical meaning
no_dem	No DEM is selected. Abar = 0.
no_profile	A valid profile could not be built: an endpoint lies outside the DEM or critical NoData is present.
los_clear	No terrain lies above the line of sight. Abar = 0.
below_threshold	Relief exists but does not exceed the threshold. Abar = 0.
active	The obstacle exceeds the threshold and diffraction is calculated by band.

Key point: intermediate NoData gaps are ignored. They are not converted to elevation 0, which avoids creating false barriers or artificial valleys.

$$z_LOS(t) = z_s,ac + t (z_r,ac - z_s,ac)$$

$$h_obs = \max_i [z_DEM,i - z_LOS(t_i)]$$



37b. Conservative threshold for activating Abar

The DEM profile activates diffraction only when relief rises above the line of sight by at least a minimum threshold. This prevents false barriers caused by numerical noise or raster resolution.

$$\text{thr} = \max(1, \min(3, 0.2 \cdot \text{pixel_size}))$$

Practical interpretation. If the maximum obstacle above the line of sight does not exceed thr, Abar remains 0 dB. If it exceeds thr, diffraction is calculated by octave band using the dominant obstacle.

38. Abar: dominant-obstacle diffraction

When Abar is active, the implementation uses one dominant knife-edge obstacle. It does not model multiple obstacles, barrier width, lateral diffraction or complex reflections.

$$\delta = (h_{\text{obs}}^2 / 2) (1/d_1 + 1/d_2)$$

Path difference for a thin obstacle at its actual position.

$$C = 2 f \delta / c$$

Fresnel number used for octave-band diffraction.



38b. Diffraction function and interpretation of Abar

Range of C	Function F(C)
C <= -2	0
-2 < C <= 0	10 log ₁₀ (3 + 20 C)
0 < C <= 3.5	10 log ₁₀ (3 + 80 C)
C > 3.5	10 log ₁₀ (3 + 280 C)

$$A_bar,b = clamp(F(C), 0, 20)$$

Abar is limited to between 0 and 20 dB per octave band.

Reading the results. abar_db is Abar for the dominant source and dominant band. abar_max_db, abar_mean_db and abar_ew_db summarise topographic screening over the set of sources contributing to the receiver.



39. Energy summation: from bands to the total receiver level

The calculation closes with two energy sums: first the A-weighted bands are combined for each source, then all sources within the receiver radius are combined.

$$L_{pA,s,r} = 10 \log_{10} [\sum_b 10^{((L_{p,b,s,r} + A_b)/10)}]$$

Spectral summation for one source at one receiver.

$$\text{noise_dba},r = 10 \log_{10} [\sum_{s \in R(r)} 10^{(L_{pA,s,r}/10)}]$$

Energy sum of all sources inside the maximum radius R(r).

Diagnostic	What it means	What it does not mean
max_src_dba	Individual source contributing most to the receiver.	It is not the total receiver level.
dom_freq	Dominant A-weighted band of the dominant source.	It does not necessarily describe all sources.
n_src	Number of sources within the radius that contribute.	It excludes turbines discarded by distance.
covered = 0	There are no sources inside the radius.	It does not mean that the receiver does not exist.



40. Noise raster: same calculation, different receiver type

The noise map is not a subsequent interpolation of point receivers. The raster is calculated by evaluating cell centres as receivers on a regular grid.

Element	Interpretation
Cell centre	Each cell is evaluated as a grid receiver. eval_mode = grid.
Map resolution	Defines the cell size and therefore the number of grid receivers.
Maximum radius	Applied exactly as for point receivers: only sources within the radius are included.
DEM	Elevation is sampled at the cell centre; if it fails, the raster route may use the documented fallback.
Land use	When enabled, it forces a slower path because each cell requires QGIS geometry intersections for G_eff.
Isophones	Extracted from the calculated raster; they do not replace checks at sensitive receivers.

Recommended use. Use the raster to visualise spatial patterns and identify critical zones. Use the Noise - Receivers layer for compliance conclusions because it contains the limit, margin, status and receiver-level audit fields.



41. Physical limitations that must be documented

This page avoids claiming more than the module actually calculates. It helps close the guide with an appropriately cautious technical tone.

Aspect	Implementation status	How to explain it in the guide
Standard	ISO-aligned, not certified.	Octave-band ISO 9613-2 structure with documented simplifications.
Aatm	Table + simple corrections.	Not the complete analytical ISO 9613-1 formulation.
Agr	Simplified source/middle/receiver regions.	G_eff enters over the whole path; no detailed regional integration of G.
Abar	Dominant DEM obstacle.	No multiple obstacles, lateral diffraction or complex artificial barriers.
Meteorology	No long-term Cmet.	T/RH/P affect Aatm; no statistical meteorological correction is applied.
Directivity	Dc = 0.	No turbine-specific directivity or rotor orientation is modelled.
Non-point receivers	Centroid.	Create specific points for façades and boundaries.
Validation	Technical screening.	Compare with validated software or measurements when required by the regulatory process.

Final message. The guide should emphasise traceability rather than over-guarantee: output fields allow users to audit the dominant source, dominant band, ground, DEM and limit. Regulatory validity depends on external validation and the applicable local framework.



42. Equation summary for auditing

Block	Key equation	Interpretation
Source-receiver	$L_p = L_w - A_{div} - A_{atm} - A_{gr} - A_{bar}$	Each path is calculated before sources are combined.
Divergence	$A_{div} = 20 \log_{10}(d3D) + 11$	Geometrical attenuation with distance.
Atmosphere	$A_{atm,b} = \alpha_b(T,RH,P) \cdot d3D$	In the ISO engine it depends on band and atmospheric conditions.
Ground	$G_{eff} = \Sigma(G_i L_i) / \Sigma L_i$	With land use, G is weighted by the distance travelled in each polygon.
Topography	$A_{bar,b} = \text{clamp}(F(C), 0, 20)$	Only when the DEM detects an active obstacle above the line of sight.
Bands	$L_pA = 10 \log_{10} \Sigma_b 10^{((L_{p,b} + A_{b,b})/10)}$	A-weighted energy summation over bands.
Receiver	$\text{noise_dba} = 10 \log_{10} \Sigma_s 10^{(L_{pA,s}/10)}$	Energy sum of all sources inside the radius.
Compliance	$\text{margin} = \text{noise_dba} - \text{limit_dba}$	Not propagation physics; this is comparison with the selected limit.

v119 closing note. This version separates inputs, the operating workflow and the implemented physics. It also makes clear that the ISO-aligned engine reproduces the structure of ISO 9613-2 while using documented simplifications for atmosphere, ground effect and topographic screening.



Technical appendix: calculation, physics and variable traceability

This appendix complements the main guide by detailing the origin of every parameter used by the physical model, how it is transformed and which output field allows it to be audited.

$$L_{p,A,r} = 10 \log_{10}(\sum_{s \in R} 10^{(L_{p,A,sr} / 10)})$$

Technical block	Plugin files/modules	Information documented in the guide
Input and configuration	noise_page.py, dialog_state.py, domain.py, validation.py	Execution-parameter dictionary: layers, radius, receiver, limit, engine, atmosphere, DTM, raster and isophones.
Acoustic sources	sources/collector.py, acoustics/curves.py, noise_spectrum.py, noise_common.py	Exact origin of X/Y, HH, D, fixed LwA, LwA(ws) curve, manual/CSV/library/template spectrum and normalisation.
Receivers	receivers/collector.py, receiver_groups.py, noise_page.py	Evaluated point, centroid, field-based height, normalised multi-layer receivers and day/night/custom limits.
Physics	noise_engine_fast.py, noise_engine_iso.py, propagation/ground.py	Fast and ISO-aligned equations, Adiv, Aatm, Agr, Abar, G_eff, A-weighting and energy summation.
DTM and outputs	qgis_io/common.py, results/evaluator.py, raster/grid.py, task_controller.py, snapshot/builder.py	NoData validity, DEM profiles, Abar states, GIS audit fields, raster as cell centres, and synchronous/task execution paths.

The code follows an ISO-aligned structure. Aatm, Agr and Abar include documented simplifications and must be interpreted within that stated scope.



1. Actual calculation flow: from QGIS to dB(A)

The calculation does not operate on continuous areas. It first converts QGIS inputs into a finite list of sources and receivers. It then evaluates source-receiver pairs within the maximum radius and sums their contributions energetically.

Step	Internal operation	Variables created	Origin
1	Read selected layers and build configuration	NoiseRunConfig	Interface controls: layers, engine, radius, receiver, limit, atmosphere, G, raster/isophones.
2	Collect sources	NoiseSource(s)	Detected/imported layouts, acoustic group configuration and DEM beneath each turbine when available.
3	Collect receivers	NoiseReceiver(r)	Single layer or temporary multi-receiver layer; point or centroid; DEM below the receiver when available.
4	Search radius candidates	S(r)	QgsSpatialIndex: ±R bounding box followed by actual horizontal-distance check.
5	Propagate each s-r pair	L_p,A,sr	Fast or ISO-aligned engine.
6	Sum sources at the receiver	noise_dba	Energy sum of all sources within the radius.
7	Apply scenario limit	limit_dba, margin_db, state	Global or layer field for day/night/custom. It changes compliance evaluation, not propagation physics.

$$S(r) = \{ s : d_{xy,sr} \leq R_{max} \}$$

$$L_{p,A,r} = 10 \log_{10}(\sum_{s \in S(r)} 10^{(L_{p,A,sr} / 10)})$$

Key fields: noise_dba is the total energetic result; max_src_dba is only the dominant source; n_src is the number of contributing sources; covered = 0 means no source lies within the radius.



2. Global run parameters and their origin

Parameter	Default / type	Origin in UI or code	Physical/GIS use
calculation_engine	fast or iso	Engine selector	Chooses global LwA or octave-band calculation.
receiver_layer	QgsVectorLayer	Receiver layer or temporary multi-receiver layer	Defines evaluation points.
source_layer_ids	list of layers	Sources / acoustic layout	Selects which turbine layouts enter as sources.
max_radius_m = Rmax	5000 m	Maximum radius	Filters sources contributing to the receiver.
receiver_height_m = h_r	4.0 m	Global receiver height	Height above ground when no group/field value is available.
min_distance_m = d_min	25.0 m	Internal parameter	Prevents singularity and non-physical distances.
dem_layer	optional	DEM/DSM	Source/receiver elevations and profile for Abar.
ground_factor_g = G0	0.5	Ground factor G	Fallback and global ground value.
ground_mode	global/landuse	Ground mode	Activates global G or land-use-derived G_eff.
landuse_layer	optional	Land-use layer	Polygons used to calculate path-based G_eff.
alpha_db_per_m	0.005 dB/m	Linear attenuation	Fast engine only; ISO uses band-dependent α .
temperature_c	15 °C	Atmospheric conditions	Correction to α in the ISO engine.
humidity_percent	70%	Atmospheric conditions	Correction to α in the ISO engine.
pressure_kpa	101.325 kPa	Atmospheric conditions	Correction to α in the ISO engine.
grid_resolution_m	100 m	Map resolution	Noise-raster cell size.
iso_levels	35,40,45,50	Isophone levels	Levels used to create isophone contours.

Execution path: without land use, the calculation can run as a QgsTask using a primitive snapshot. When land use is enabled, the code forces the synchronous path because G_eff polygon intersections still use QGIS geometry.



3. Acoustic source: NoiseSource variables

Variable	How it is obtained	Use in calculation	Output/audit
x_s, y_s	Layout feature point	Distance, s-r line, radius filter, G_eff, DEM profile	Noise Sources; dominant links
model_name	velantis/model_name property or layer name	Model matching and traceability	dom_model
source_group	Group configuration or layer name	Groups turbines with the same acoustic setup	dom_group
park_name	Park property/configuration	Origin traceability	dom_park
HH_s = hub_height	Acoustic source-group configuration table	Acoustic source elevation z_s + HH_s; ground effect and 3D geometry	hub_h_m, src_ac_z_m
D	Model configuration when available	Traceability; not directly used in current acoustic propagation	Noise Sources / diagnostics
LwA_s	Fixed value, LwA(ws) curve or A-sum of absolute spectrum	Fast engine and ISO fallback; spectrum normalisation	src_lwa, spec_src
Lw_b,s	Manual/CSV/library/template/fallback spectrum	ISO engine by band	spec_src, dom_freq
z_ground_s	DEM under the turbine when available	Source elevation and Abar line of sight	src_z_m, maxab_src_z
feature_id	QGIS turbine feature ID	Internal traceability	source_feature_id in diagnostics

$$z_src,ac = z_ground,src + HH_src$$

$$L_w,A,oper = L_w,A,fixed \text{ or } \text{interp}(ws_eval; ws, L_w,A) \text{ or } 10 \log_{10} \sum_b 10^{((L_w,b + A_b)/10)}$$



4. Acoustic emission: modes, priorities and equations

Mode	Input	Implemented rule	Risk to document
Fixed LwA	dB(A) value per group	Used as the operating LwA of all turbines in the group.	Does not represent wind-speed dependence unless a curve is imported.
LwA(ws) curve	Two numeric CSV columns: ws, LwA	Linear interpolation at ws_eval; nearest endpoint outside range; duplicates keep the maximum; worst-case uses the curve maximum.	Do not confuse it with electrical power or Ct.
Manual spectrum	8 octave-band values	If it appears relative, it is normalised to LwA; if absolute and not normalised, it can redefine operating LwA through the A-weighted sum.	Review spec_src.
OEM CSV	freq_hz + Lw_dB / LwA_dB / Lw_dB_rel	Priority: Lw > LwA > relative. LwA_b is converted to Lw_b = LwA_b - A_b to prevent double weighting.	Small LwA_b values are rejected as ambiguous when they resemble a relative shape.
Library/template	spectrum_library and templates	Conservative matching by manufacturer + family; generic_large/small/modern fallback according to power.	Templates are not OEM certification.

$$L_{w,A,curve} = \text{interp}(ws_eval; ws_i, L_{w,A,i})$$

$$L_{w,b} = L_{w,A,b} - A_b$$

$$\Delta = L_{w,A,target} - 10 \log_{10} \sum_b 10^{((S_b + A_b)/10)}; \quad L_{w,b} = S_b + \Delta$$



5. Receivers, scenarios and multiple layers

Variable/field	Origin	Rule	Output field
x_r, y_r	Receiver geometry	Point: direct coordinate. Line/polygon: centroid. Multi-layer: a temporary point layer is created.	eval_mode
h_r	Global value or grp_h_m field	Single layer: receiver_height_m. Multi-layer: height from each row/category.	rec_h_m, rec_ac_z_m
z_ground_r	DEM below receiver	If a valid DEM value exists it is used as ground elevation; otherwise None/0 depending on the geometry route.	rec_z_m
rec_type	Receiver field or grp_type	Category label used for summaries and compliance by type.	rec_type
limit_day	grp_lim_d or selected field	Applied only when receiver_limit_mode=by_field and scenario=day.	limit_dba, limit_scn, limit_fld
limit_night	grp_lim_n or selected field	Applied only for the night scenario.	limit_dba
limit_custom	grp_lim_c or global value	Applied in the custom scenario. In the current multi-layer workflow grp_lim_c is the global interface limit.	limit_dba
grp_src	Original layer name	Shows which original layer each multi-category receiver came from.	src_layer

$$z_{rec,ac} = z_{ground,rec} + h_r$$

$$margin_r = L_{p,A,r} - limit_{r,scenario}$$

$$state = \begin{cases} \text{exceeds} & \text{if } margin > 0; \\ \text{near_limit} & \text{if } -3 < margin \leq 0; \\ \text{compliant} & \text{if } margin \leq -3 \end{cases}$$

Important: the day/night/custom scenario does not change the calculated noise. It changes the comparison limit. Two scenarios with identical physics therefore have the same noise_dba but different margin_db/state when their limits differ.



6. 3D geometry and distances

Each source-receiver pair uses horizontal distance for the radius filter and ground effect, and 3D distance for divergence and atmospheric absorption. The ISO engine also enforces $d_{xy} \geq d_{min}$ before calculating 3D distance; the fast engine uses d_{min} as a floor inside the square root.

$$d_{xy,sr} = \sqrt{(x_s - x_r)^2 + (y_s - y_r)^2}$$

$$d_{3D,sr} = \max[d_{min}, \sqrt{(d_{xy,sr})^2 + (z_{src,ac} - z_{rec,ac})^2}]$$

$$A_{div} = 20 \log_{10}(d_{3D}) + 11$$

Parameter	Origin	Use
d_xy	Layout and receiver coordinates	Radius filter, G_eff, Agr regions and raster.
d_3D	d_xy plus acoustic elevations	Adiv and Aatm.
d_min	Internal constant: 25 m	Prevents log(0) and unrealistic propagation distances.
z_src_ac	DEM below turbine + HH	Line of sight and 3D distance.
z_rec_ac	DEM below receiver + h_r	Line of sight and 3D distance.



7. Fast engine: equations and parameters

The fast engine works in broadband A-weighted sound. It is useful for screening because it needs few inputs and runs quickly, but it does not propagate octave bands or apply frequency-dependent meteorology.

$$L_{p,A,sr} = L_{w,A,s} - A_{div} - A_{atm,simple} - A_{ground,simple}$$

$$A_{atm,simple} = \alpha_{lin} \cdot d_{3D}$$

$$base = 3 \log_{10}(1 + d_{xy}/100); \quad H = 1 / [1 + (HH_s + h_r)/80]$$

$$A_{ground,simple} = clip(G \cdot base \cdot H, 0, 6 \text{ dB})$$

Variable	Value/origin	Interpretation
α_{lin}	Linear attenuation in the interface; default 0.005 dB/m	Frequency-independent linear atmospheric absorption.
G	Global ground_factor_g	The current propagate_fast route uses global G. Raster/ground helpers may use land use in synchronous configurations.
base	Function of d_{xy}	Makes the ground effect increase with distance.
H	$HH + h_r$	Reduces ground effect when source and receiver are high.
clip 0-6 dB	Internal limit	Prevents excessive ground attenuation in screening.

Keep this section separate from ISO-aligned: its Aatm and Aground are not equivalent to the octave-band terms used by the ISO engine.



8. ISO-aligned engine: octave-band model

The ISO-aligned engine propagates eight octave bands and performs A-weighted summation at the end. Dc/directivity is taken as 0 dB in the current implementation. No long-term meteorological correction Cmet is applied.

$$L_{p,b,sr} = L_{w,b,s} + D_c - A_{div} - A_{atm,b} - A_{gr,b} - A_{bar,b}$$

$$D_c = 0 \text{ dB}; \text{ } C_{met} \text{ not applied}$$

$$L_{p,A,b,sr} = L_{p,b,sr} + A_b$$

$$L_{p,A,sr} = 10 \log_{10} \sum_b 10^{(L_{p,A,b,sr} / 10)}$$

Band b	63	125	250	500	1000	2000	4000	8000
A_b [dB]	-26.2	-16.1	-8.6	-3.2	0.0	+1.2	+1.0	-1.1

The adiv_db, aatm_db, aground_db and abar_db fields shown in the receiver layer refer to the dominant source path and, in the ISO engine, to that source's dominant A-weighted band. They are not averages over all bands or turbines.



9. Aatm: implemented atmospheric absorption

The structure is ISO-aligned, but the alpha coefficient does not implement the complete analytical formulation of ISO 9613-1. The code uses a base table by band and simple factors for temperature, humidity and pressure.

$$A_{atm,b} = \alpha(f_b, T, RH, P) \cdot d_{3D}$$

$$\alpha = \alpha_{ref,b} [1 + 0.01(T - 15)] [1 + 0.003(RH - 50)] \cdot 101.325 / P$$

Band [Hz]	63	125	250	500	1000	2000	4000	8000
α_ref [dB/m]	0.0001	0.0003	0.0008	0.0020	0.0040	0.0095	0.0280	0.0900

Variable	Origin	Notes
T	sp_temperature	Default 15 °C. Simple linear factor relative to 15 °C.
RH	sp_humidity	Default 70%. The relative minimum is approximated near 50%.
P	sp_pressure	Default 101.325 kPa. Inverse pressure factor.
α_ref	Internal table	Typical values for reference conditions.

In the guide this should be described as simplified octave-band Aatm, not the complete analytical ISO 9613-1 formulation. It is traceable and internally consistent, but external validation is required for regulatory submissions.



10. G_eff and Agr: ground from global G or land use

The G factor represents hard/soft ground: 0 hard or reflective, 1 porous or soft. With land use enabled, the effective G of each source-receiver pair is calculated along the s-r line, not only at the receiver location.

$$G_{eff,sr} = \sum_i G_i L_i / \sum_i L_i$$

$$A_{gr,b} = clip(A_{s,b} + A_{m,b} + A_{r,b}, 0, 10 \text{ dB})$$

$$d_s = \min(30H_s, d/3), \quad d_r = \min(30h_r, d/3), \quad d_m = \max(d - d_s - d_r, 0)$$

Element	Rule
Numeric fields	Searches g_factor, g, ground_g, g_value or G. The first finite value is clipped to [0,1] and has priority.
Text fields	uso_suelo, uso, clase, landuse, cover or type. Urban/asphalt/rock = 0; mixed/mosaic = 0.5; crops/grass/forest/porous soil = 1.
Intersection	The source-receiver line is intersected with candidate polygons by bounding box. Each segment contributes G_i according to its length L_i.
Fallback 1	If there is no line intersection, the path midpoint is tested.
Fallback 2	If there is no polygon at the midpoint, global G is used.

Audit: review ground_md and ground_g. If ground_mode=landuse but ground_g always equals the global value, the path probably does not intersect valid polygons or the calculation has fallen back to global G.



11. Base Agr function by frequency

The code does not reproduce every detailed ISO 9613-2 ground equation literally. It implements source/middle/receiver regions and a base function by band and characteristic height, then weights it by G_{eff} .

$$A_{s,b} = G_{eff} \cdot a_{ground}(f_b, H_s)$$

$$A_{m,b} = G_{eff} \cdot a_{ground}(f_b, (H_s + h_r)/2) \quad \text{if } d_m > 0$$

$$A_{r,b} = G_{eff} \cdot a_{ground}(f_b, h_r)$$

Frequency	Implemented $a_{ground}(f,h)$
$f \leq 500 \text{ Hz}$	1.5 dB
1000 Hz	$1.5 \cdot [1 - \exp(-h/10)]$
2000 Hz	$3.0 \cdot [1 - \exp(-h/10)]$
4000 Hz	$6.0 \cdot [1 - \exp(-h/10)]$
8000 Hz	$12.0 \cdot [1 - \exp(-h/10)]$

Physical interpretation: Agr behaves as positive attenuation that increases with porous ground and with certain bands/heights, and is capped at 10 dB. It should not be presented as a complete ISO ground-interference implementation; it is a traceable regional approximation.



12. DTM/DEM and Abar: profile, obstacle and diffraction

The DEM does not modify emission. It modifies geometry and allows approximate topographic screening when one dominant obstacle lies above the source-receiver line of sight.

$$z_LOS(t) = z_src,ac + t (z_rec,ac - z_src,ac)$$

$$h_obs = \max_i [z_DEM(i) - z_LOS(i)]$$

$$threshold = \max(1 \text{ m}, \min(3 \text{ m}, 0.2 \cdot pixel_size))$$

Variable/state	Origin/rule	Output
DEM endpoint elevations	Samples below source and receiver. They must be valid; NoData is not converted to zero.	src_z_m, rec_z_m
Profile	Target step roughly follows DEM resolution; practical minimum 5 m; 50-1200 points for receivers.	mdt_sample_step, mdt_num_points
no_dem	No DEM is selected.	abar_state=no_dem; Abar=0
no_profile	DEM exists but endpoint/profile is invalid.	Abar=0 to avoid false barriers.
los_clear	$h_obs \leq 0$.	Clear line of sight; Abar=0
below_threshold	$0 < h_obs \leq threshold$.	Relief exists but does not activate Abar.
active	$h_obs > threshold$.	Abar is calculated using Fresnel diffraction.



13. Abar: implemented Fresnel diffraction

When the obstacle is active, the code uses a thin-edge approximation with actual d1 and d2 values taken from the position of the dominant obstacle in the profile.

$$\delta = (h_{obs}^2 / 2) (1/d_1 + 1/d_2)$$

$$C = 2 f \delta / c; \quad c = 343 \text{ m/s}$$

$$A_{bar,b} = \text{clip}(F(C), 0, 20 \text{ dB})$$

Range of C	F(C) used in code	Interpretation
C <= -2	0	No significant obstacle.
-2 < C <= 0	10 log ₁₀ (3 + 20 C)	Transition zone.
0 < C <= 3.5	10 log ₁₀ (3 + 80 C)	Partial obstacle.
C > 3.5	10 log ₁₀ (3 + 280 C)	Significant obstacle.

Audit fields: abar_db is Abar for the dominant path; abar_max_db is the maximum among contributing sources; abar_mean_db is the mean; abar_ew_db is the energy-weighted mean; maxobs_* shows the largest candidate obstacle even when it does not activate Abar.



14. Noise raster and isophones

The raster does not calculate a continuous analytical surface. It creates a grid and evaluates each cell centre as a grid receiver using the same source-receiver logic. Isophones are then extracted from the raster at the configured levels.

$$x_{cell} = x_{min} + (j + 0.5) \text{ res}; \quad y_{cell} = y_{max} - (i + 0.5) \text{ res}$$

$$L_{p,A,cell} = 10 \log_{10} \sum_{s \in S(cell)} 10^{(L_{p,A,s,cell} / 10)}$$

Parameter	Rule
Extent	Source bounding box expanded by pad = max(Rmax, 2·res, 100 m).
Effective resolution	If the grid exceeds max_cells=150000, res is increased to control processing cost.
NoData	Cells without a contribution are assigned nodata = -9999.
Land use	When enabled, the calculation is not fully vectorised because each path requires QGIS geometry intersections.
DEM	The raster samples the DEM by cell; accelerated routes may use more limited profile-sampling budgets.

Recommended use: use the raster to visualise spatial patterns and locate critical zones. Use Noise - Receivers for compliance conclusions because it retains limits, margin, state and receiver-level audit fields.



15. Output fields: meaning of each diagnostic

Field	Meaning	Origin
noise_dba	Total A-weighted level at the receiver	Energy sum of all sources within Rmax.
n_src	Number of contributing sources	Spatial filter plus actual distance check.
near_m	Horizontal distance to the nearest source	Minimum d_xy among contributing sources.
max_src_dba	Dominant individual contribution	Maximum Lp_A,sr, not the total sum.
dom_model / dom_group / dom_park	Dominant source	Taken from the source that produces max_src_dba.
src_lwa	Operating LwA of the dominant source	Fixed value, curve or spectrum.
dist3d_m	3D distance of the dominant path	Source-receiver geometry.
adiv_db / aatm_db / aground_db / abar_db	Breakdown of the dominant path	Fast: broadband. ISO: dominant A-weighted band of the dominant path.
ground_g	G used on the dominant path	Global G or land-use-derived G_eff.
dom_freq	Dominant band	ISO only; band with the largest Lp + A.
spec_src	Spectrum origin	Manual, CSV, library, template or fallback.
eval_mode	point / centroid / grid	How the receiver evaluation point was constructed.
covered	1 if sources lie within Rmax	0 if the receiver is moved to outside-radius output.
limit_dba / margin_db / exceeds / state	Compliance	Global or field-based limit according to scenario.



16. DTM and Abar fields: correct interpretation

Field	Correct interpretation
abar_state	DTM state of the dominant path: no_dem, no_profile, los_clear, below_threshold, active or no_screening.
obs_h_m	Height of the dominant obstacle above the line of sight on the dominant path.
obs_d1_m / obs_d2_m	Source-obstacle and obstacle-receiver distances only when the path is active.
obs_thr_m	Activation threshold used to decide whether Abar is applied.
src_z_m / rec_z_m	DEM ground elevations below source/receiver on the dominant path.
src_ac_z_m / rec_ac_z_m	Absolute acoustic elevations used in the line-of-sight calculation.
abar_max_db	Maximum Abar among contributing sources; not necessarily the energetically dominant source.
abar_mean_db	Simple mean Abar among contributing sources.
abar_ew_db	Abar mean weighted by the acoustic energy of each source.
abar_screen_n	Number of sources with active Abar or Abar greater than 0.005 dB.
maxab_*	Path with the largest active Abar.
maxobs_*	Path with the largest candidate obstacle, even below threshold and with Abar=0.

To debug the DTM, abar_db alone is not enough. When abar_db=0, maxobs_h and maxobs_thr show whether topography exists but remained below the activation threshold.



17. Complete technical glossary of calculation variables

s	-	Source/turbine index	Source summation and dominant diagnostics.
r	-	Receiver index	Evaluated point.
b	Hz	Octave band: 63-8000 Hz	ISO engine.
x_s, y_s	m	Turbine layout	Geometry.
x_r, y_r	m	Receiver or centroid	Geometry.
z_ground_s	m	DEM below turbine	Source ground elevation.
z_ground_r	m	DEM below receiver	Receiver ground elevation.
HH_s	m	Configured hub height	Acoustic source elevation, Agr.
h_r	m	Global or category receiver height	Acoustic receiver elevation, Agr.
d_xy	m	Horizontal distance	Filter, Agr, G_eff.
d_3D	m	3D distance	Adiv, Aatm.
Rmax	m	Maximum radius	Candidate sources.
d_min	m	Internal constant: 25 m	Prevents singularity.
LwA	dB(A)	Fixed/curve/spectrum	Fast engine and normalisation.
Lw_b	dB	Octave spectrum	ISO engine.
A_b	dB	A_WEIGHTING table	A-weighting.
Adiv	dB	$20 \log_{10}(d_{3D}) + 11$	Divergence.
alpha	dB/m	Simplified ISO table/corrections	ISO Aatm.
Aatm	dB	alpha-d	Atmospheric absorption.
G0	-	Global ground factor	Ground fallback.
G_eff	-	Land use or G0	Agr or Aground.
Agr	dB	Source/middle/receiver regions	ISO-aligned ground effect.
Aground	dB	Fast empirical equation	Fast ground effect.
Abar	dB	DEM profile + Fresnel	Topographic screening.
h_obs	m	Maximum above LOS	Activates diffraction.
d1, d2	m	Obstacle position	Fresnel calculation.
delta	m	Path difference	Fresnel number.
C	-	$2f \cdot \delta / c$	Abar function.
Lp_b	dB	Band result	A-weighted summation.



17. Complete technical glossary (continued)

Variable	Unit	Origin	Use
LpA_sr	dB(A)	Band summation or fast engine	Individual source contribution.
LpA_r	dB(A)	Source summation	noise_dba
limit_r	dB(A)	Global value or field	Compliance.
margin	dB	noise - limit	state / exceeds



18. Traceability checklist for consultancy

Audit question	Where to verify it
Is the receiver layer correct and not the turbine layout?	Check configuration; layer name; eval_mode.
Was a point or a centroid used?	eval_mode and description of the original geometry.
Is the applied limit global or from a layer/category?	limit_src, limit_scn, limit_fld, limit_dba.
Does the day/night scenario change the physical calculation?	No. It changes only limit, margin and state.
Does LwA come from a fixed value, curve or spectrum?	src_lwa, spec_src and the source-group table.
Was the spectrum normalised or did it redefine LwA?	spec_src should indicate normalised or spectrum-based LwA(A).
Was the DEM actually used?	src_z_m, rec_z_m, abar_state, obs_thr_m.
Why is Abar zero?	abar_state, maxobs_h, maxobs_thr.
Is land-use G being applied?	ground_md=landuse and ground_g varying from global G.
Does the raster use the requested resolution?	grid_diag: requested_resolution_m, effective_resolution_m, auto_adjusted.
Does the maximum receiver exceed the limit or is it only close?	noise_dba, margin_db, state.

Recommended report sentence: "The receiver result is an energetic sum of sources. Dominant-source columns are included for audit and diagnosis, but they do not replace the total noise_dba level."



19. Physical limitations that must remain visible

Topic	Implemented status	How to describe it in the guide
ISO-aligned	ISO 9613-2 octave-band structure	Do not say “fully ISO certified”; say “aligned with the ISO structure”.
Aatm	Base table + T/RH/P corrections	Simplified octave-band absorption, not the full analytical ISO 9613-1 model.
Agr	Source/middle/receiver regions + base function	Traceable ground-effect approximation, capped at 10 dB.
Abar	Dominant obstacle + Fresnel	No multiple or lateral diffraction; one dominant obstacle.
Directivity	Dc = 0	Omnidirectional source in this version.
Cmet	Not applied	No long-term meteorological correction.
Spectra	Octaves 63-8000 Hz	No one-third-octave bands.
Land use	QGIS line intersection	Requires common CRS and valid polygons; global G is used on fallback.
DEM	Conservative NoData treatment	Gaps are not converted to elevation zero, preventing false barriers.

This page is essential for a defensible guide: it explains what the software does and also what it does not do.



1. Module scope and recommended public wording

This block summarises the module scope and proposes a clear public description without promising complete regulatory certification.

- It is not a certified regulatory acoustic report. It does not replace a final study with external validation when required by the permitting process.
- The correct wording is ISO-aligned / aligned with the ISO structure, not fully ISO-compliant.
- The receiver result is an energetic sum of sources. Dominant columns support audit and diagnosis but do not replace the total noise_dba value.
- It does not include Cmet, directivity, one-third-octave bands or multiple barriers.
- It should be presented as a technical screening and alternative-comparison tool, not as certified regulatory software.

Short module description. The VelantisWind noise module calculates dB(A) levels at point receivers from wind-turbine sources, source-group acoustic emission, atmospheric conditions, ground effect and, optionally, DEM/DSM and land use. It is intended for technical screening and comparison of alternatives, with physics aligned with the ISO 9613-2 structure and documented simplifications.



2. Calculation engines: fast, octave-band ISO and 500 Hz approximation

This section distinguishes the fast and ISO routes and also documents the 500 Hz approximation that may appear in code or diagnostics.

Route	How it calculates	When to use it	Key limitation
Fast / screening	Uses global LwA, Adiv, simplified linear Aatm, empirical Aground and energy summation over sources.	First test, layer debugging and quick response.	No octave-band spectrum or frequency-dependent Abar.
ISO-aligned by band	Calculates Lp_b for octave bands 63-8000 Hz with Adiv, Aatm_b, Agr_b, Abar_b and A-weighting.	Technical review and comparison with other software.	Not a complete ISO 9613-1/2 implementation; uses declared simplifications.
ISO 500 Hz approx	Estimates LpA using the 500 Hz attenuation terms as a compact approximation.	Quick diagnosis or technical fallback if that function is used.	Does not replace the full octave-band calculation. Document it as an approximation.

Fast

$$L_{pA,sr} = L_{wA,s} - A_{div} - A_{atm} - A_{ground}$$

$$A_{ground} = clip[G \cdot 3 \log_{10}(1 + d_{xy}/100) \cdot 1/(1 + (HH + h_r)/80), 0, 6]$$

ISO by octave band

$$L_{p,b,sr} = L_{w,b,s} - A_{div} - A_{atm,b} - A_{gr,b} - A_{bar,b}$$

$$L_{pA,r} = 10 \log_{10} \sum_s \sum_b 10^{((L_{p,b,sr} + A_b)/10)}$$

3. From equation to input: origin of each physical variable

This table connects the model physics to practical input preparation.

Variable	Input/origin	Field/control	Output audit
x_s, y_s	Turbine layout	CSV x,y or point geometry	Noise - Sources, Dominant links
x_r, y_r	Receiver layer	Point or centroid of polygon/line	Noise - Receivers, eval_mode
HH_s	Source group	HH [m] in the acoustic table	src_ac_z_m when DEM exists
h_r	Receiver	Global receiver height or grp_h_m	rec_ac_z_m
z_ground_s, z_ground_r	DEM/DSM	Selected raster	src_z_m, rec_z_m
LwA	Source emission	Fixed LwA, LwA(ws) curve or absolute spectrum	src_lwa, spec_src
Lw_b	Spectrum	OEM CSV or fallback spectrum	dom_freq, spec_src
G0	Global ground	Ground factor G	ground_md=global
G_eff	Land use	g_factor/text field along the path	ground_md=landuse, ground_g
T, RH, P	Atmosphere	Temperature, Relative humidity, Pressure	aatm_db, ISO engine
Rmax	Radius	Maximum radius	covered, n_src, outside radius
limit_r	Compliance	Global/day/night/custom	limit_dba, limit_src, limit_scn, state



4. Layers and reports: module deliverables and interpretation

The outputs are not only receiver dB(A) values; they are a set of layers and reports designed for auditing.

Output	Content	Purpose
Noise - Receivers	One point per evaluated receiver with noise_dba, limit, margin, state and diagnostics.	Main result and compliance.
Noise - Sources	Used sources, group, operating LwA, spectrum and elevations.	Audit acoustic inputs and turbine model.
Noise - Dominant links	Line from each receiver to its dominant source.	Explain which turbine dominates and review distances.
Noise - Receivers outside radius	Receivers with no candidate source within Rmax.	Detect insufficient radius or incorrect CRS.
Noise map raster	Grid of cell centres evaluated as receivers.	Noise map and isophones.
Isophones	Contours extracted from the raster at configured levels.	GIS visualisation for reports.
HTML/TXT/XLSX reports	Configuration, inputs, results and warning summary.	Traceable delivery, user review and case archive.

Audit sentence: “noise_dba is the total A-weighted level. max_src_dba, dom_freq, abar_db, ground_g and spec_src explain the dominant path or the conditions used, but they are not the total result by themselves.”



5. DTM/Abar fields: detailed interpretation that must be retained

This table provides a useful reading of DTM/Abar fields for troubleshooting.

Field	Correct interpretation	Misinterpretation to avoid
abar_state	State of the dominant path: no_dem, no_profile, los_clear, below_threshold, active or no_screening.	Do not assume Abar=0 always means the DEM was not used.
obs_h_m	Height of the dominant obstacle above the line of sight on the dominant path.	Do not confuse it with absolute terrain elevation.
obs_d1_m / obs_d2_m	Source-obstacle and obstacle-receiver distances when the path is active.	Do not expect values when Abar is inactive.
obs_thr_m	Activation threshold used to decide whether Abar applies.	A small obstacle may remain below_threshold.
src_z_m / rec_z_m	DEM elevations below source/receiver on the dominant path.	These are not hub height or receiver height.
src_ac_z_m / rec_ac_z_m	Absolute acoustic elevations used in the line of sight.	Do not mix ground elevation with acoustic elevation.
abar_max_db	Maximum Abar among contributing sources.	It need not match the energetically dominant source.
abar_ew_db	Energy-weighted mean Abar.	Do not compare it with the simple mean without understanding the weighting.
abar_screen_n	Number of paths with significant or active Abar.	Remember the small counting threshold.
maxab_* / maxobs_*	Path with the largest Abar / largest candidate obstacle.	Useful for debugging even when it is not the dominant path.



6. Check configuration: validations worth listing

The guide should make clear that Check configuration is not decorative: it prevents most silent GIS-preparation errors.

Group	What it validates	Practical message
Layers	Selected sources, non-empty receivers, raster DEM, polygonal land use.	If a layer does not appear, press Refresh. If it appears but fails, review CRS and geometry type.
CRS	Matching CRS for project, sources, receivers, DEM and land use.	Do not calculate in degrees or mix latitude/longitude with UTM.
Numeric parameters	Radius, resolution, height, limit, alpha, G, temperature, humidity, pressure.	Negative or non-finite values stop or degrade the calculation.
Emission	Fixed LwA, curve, spectrum, groups and CSV paths.	If a curve/spectrum fails, review headers and units.
Multi-layer receivers	Type, height and day/night/custom limits per layer.	Custom layer fields are not mapped automatically outside the normalised workflow.
Raster/isophones	Resolution and list of levels.	If levels cannot be parsed, use the fallback or comma-separated values.

Recommended order before calculation: Refresh -> select inputs -> Check configuration -> review summary -> Calculate noise. After changing layers, always Refresh; after changing parameters, always Check configuration.

Publication note. Public version prepared for release, including the reinforced land-use/G section and the compatible GeoPackage example.