



AIRTURB

## Wind Resource Assessment Pro

document

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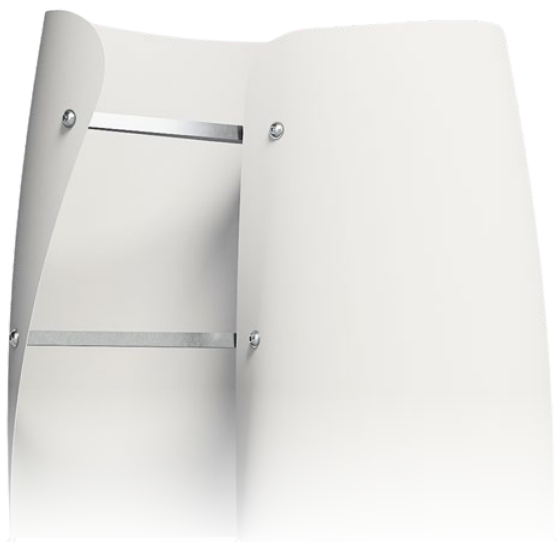
**MADE FOR**

Company  
Spaces  
Hofplein

document

**PREPARED ON**

Date  
31 October  
2025



# Overview

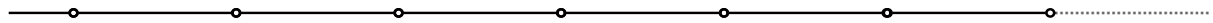
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# Purpose

This report evaluates the local wind conditions and energy potential for the Airturb Model One at the Hofplein 20 site in Rotterdam. Using long-term ERA5 reanalysis data (2016–2025), adjusted for local terrain and exposure, the study provides a realistic estimate of wind availability and expected energy yield at hub height.

The analysis includes directional and seasonal wind behavior, height-sensitivity effects, and obstacle influences to identify optimal siting and installation strategy. Model-specific power curves and loss assumptions are applied to calculate annual and monthly energy production, expressed in both kWh and € value, along with corresponding CO<sub>2</sub>-avoidance estimates.

Additionally, an economic and environmental evaluation quantifies the Levelised Cost of Energy (LCOE), return on investment (ROI), and carbon offset benefits. Together, these insights enable a data-driven assessment of technical feasibility, visual impact, and sustainability performance for the proposed installation.



# Disclaimer

All wind speed and energy figures in this report are modelled estimates from long-term datasets with height adjustments and urban exposure corrections. Results may change if input data or standard methods are updated. Actual production varies with building-scale effects, turbulence, seasonal anomalies, temporary obstructions, electrical integration, and maintenance. Values are estimates with an uncertainty of 20% to 35% depending on site complexity. Short monitoring periods seldom reflect long-term conditions.

Where available, acceptance should rely on representative on-site monitoring with agreed data coverage and normalisation via a wind index to compare measured output with the central estimate. If no on-site measurements are available, the local wind climate is determined using the best available datasets. Availability and quality of such data directly affect uncertainty. Airturb accepts no liability for conclusions based on third-party data used in this analysis.

This document has been prepared for the stated purpose, site, height, and loss budget. It should not be used for other purposes. Responsibility for the use of the findings remains with the client. This report does not constitute a production guarantee or financial advice. Airturb Model One is a Savonius Vertical Axis Wind Turbine designed for turbulent, multi-directional urban flows. Its omnidirectional rotor and low cut-in speed improve resilience to rapid direction shifts. Variability remains. Deviations in installation or environment may affect outcomes.



# Methodology & data sources

This analysis combines high-resolution atmospheric reanalysis data with site-specific adjustments to represent the wind conditions at the exact installation height. ERA5 single-level data from the European Centre for Medium-Range Weather Forecasts (ECMWF) provides the core dataset, covering the period 2016–2025 with an hourly resolution. The data is spatially filtered to the coordinates of Hofplein, Rotterdam, and corrected for local surface roughness, exposure, and elevation. Wind speeds are extrapolated to the hub height of 95 meters using the power-law wind profile,

All derived metrics, including directional roses, Weibull distributions, and height-sensitivity curves, are computed from the ERA5 time series. The dataset is processed through a standardised analytical procedure that ensures repeatable results and consistent reporting. Energy yield calculations apply the power coefficient and loss assumptions defined for the Airturb Model One, incorporating generator and inverter efficiencies. This provides a reliable and traceable estimate of wind potential, tailored to urban environments where measured data is often unavailable.



# Executive Summary

|               |                                     |
|---------------|-------------------------------------|
| Document ID   | AIR-20251410-AIRBV-01-V1            |
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|                 |                   |                 |        |
|-----------------|-------------------|-----------------|--------|
| Product         | Airturb Model One | Hybrid Inverter |        |
| Configuration   | Solar Base        | n/a             |        |
| Wind Power      | 10 Units          | Capacity: 1000W | 10 kW  |
| Solar Power     | 40 Units          | Capacity: 30W   | 1.2 kW |
| System Capacity | 11.2 kW           |                 |        |



figure 1 – hofplein 20, Rotterdam [source: funda 2025]



# Summary

| Field                              | Value    |
|------------------------------------|----------|
| Latitude                           | 51.9244  |
| Longitude                          | 4.4777   |
| Hub height [m]                     | 95.0     |
| Mean Wind Speed [m/s]              | 6.938    |
| Weibull k                          | 2.103    |
| Weibull c [m/s]                    | 7.851    |
| Mean power [W]                     | 69.486   |
| Annual Wind Energy [kWh/yr]        | 597.859  |
| Annual Solar Energy [kWh/yr]       | 100.000  |
| Mean 2 m Temperature [°C]          | 11.495   |
| Mean Surface Pressure [hPa]        | 1015.361 |
| Air density [(kg/m <sup>3</sup> )] | 1.243    |
| Rotor Surface A [m]                | 1.00     |
| Power Coefficient [Cp]             | 0.20     |
| Nominal Wind Power [Watt]          | 1000.00  |
| Nominal Solar Power [Watt]         | 120.00   |
| Generator + Inverter Efficiency    | 0.90     |
| Files used                         | 118      |

# Summary

**Scope.** Wind resource was assessed for the selected point in Rotterdam (51.9244°N, 4.4777°E) at a hub height of 95 m for the Airturb Model One.

**Method.** Ten years of ERA5 single-levels were processed to hourly u/v winds at 10 m and 100 m. We derived hub-height speed using a stability-aware shear, fit a Weibull distribution, and produced direction roses, monthly climatology, and height-sweep results. Electrical output was computed from  $P = \frac{1}{2} \times \rho \times A \times U^3$ .

with  $C_p=0.20$  and 90 % electrical efficiency. Mean 2 m temperature and surface pressure gave air density via the ideal-gas relation. The analysis used 118 monthly files from January 2016 to October 2025.

**Key results.** Mean wind speed at 95 m is 6.94 m/s, with Weibull  $k = 2.10$  and  $c = 7.79$  m/s. Mean 2 m temperature is 11.49 °C and mean surface pressure 1015.36 hPa, giving air density  $\approx 1.24$  kg/m<sup>3</sup>. Mean wind power is 69.5 W. Net annual wind energy for Model One is  $\sim 597.86$  kWh/yr at 95 m. Height sweeps and monthly profiles show stronger winter production and steady gains with elevation.

# Terrain Analysis

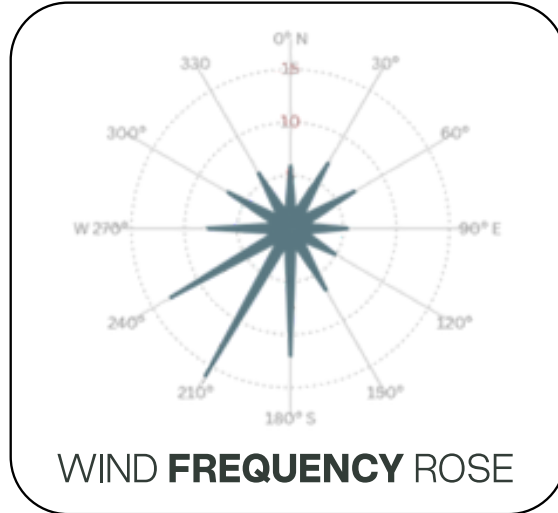
|                                     |                       |
|-------------------------------------|-----------------------|
| <b>Address</b>                      | Hofplein 20           |
| <b>Wind Zone</b>                    | 2                     |
| <b>Coordinates</b>                  | 51.9244° N; 4.4777° E |
| <b>Terrain Category</b>             | urban / dense built   |
| <b>Typical <math>z_0</math> (m)</b> | 2.0 m – 3.0m          |
| <b>Rooftop Height</b>               | 95 m                  |

| Obstacle | Distance | Height | D/H  | Vertical clearance $\alpha$ | Compass            |
|----------|----------|--------|------|-----------------------------|--------------------|
| 1        | 240m     | 106m   | 2.26 | -2.6°                       | 247° – 257°<br>WSW |
| 2        | 450m     | 150m   | 3.00 | -7.0°                       | 250° – 263°<br>WSW |
| 3        | 330m     | 87m    | 3.79 | +1.39°                      | 250° – 261°<br>WSW |

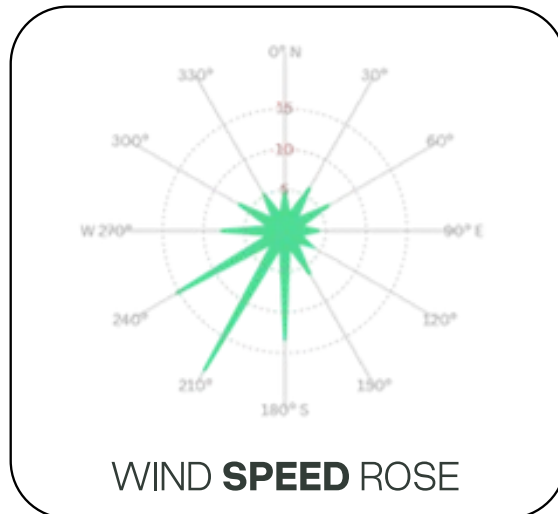
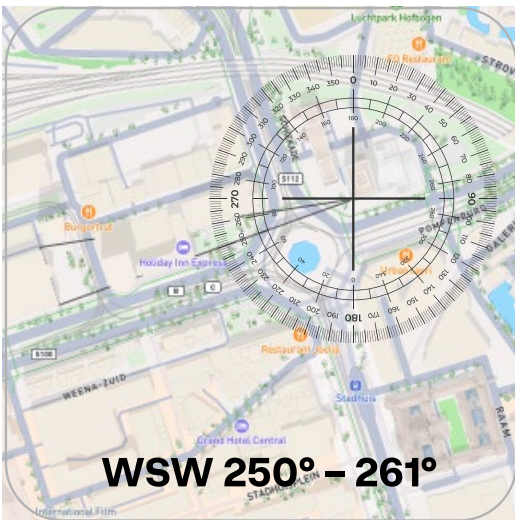


figure 2 – building heights [source: apps.webmapper 2025]

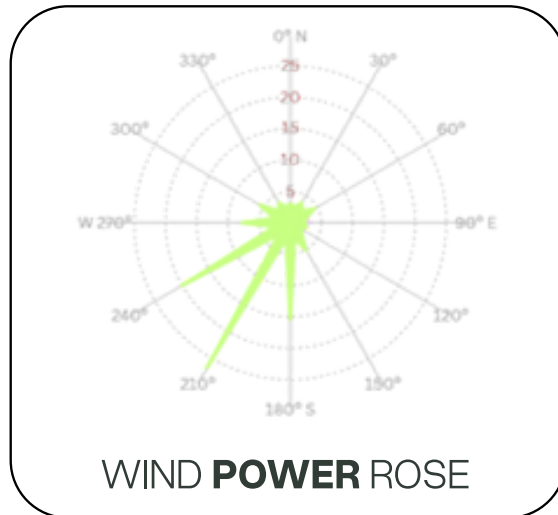
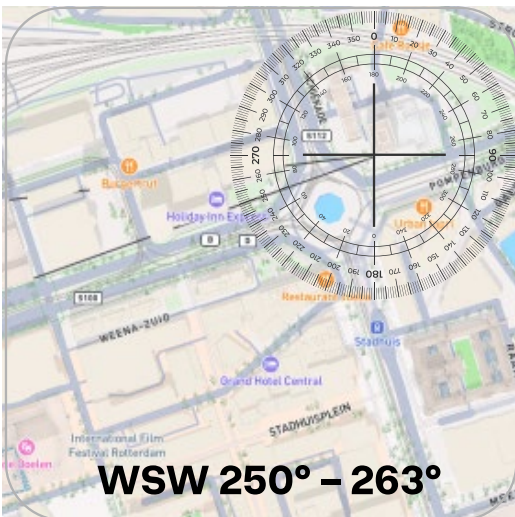
# Terrain Analysis



WIND **FREQUENCY** ROSE



WIND **SPEED** ROSE



WIND **POWER** ROSE

figure 3 - Top view [geojson.io 2025]

figure 4 - Roses [Flourish 2025]



# Terrain Analysis

The obstacle survey identifies three tall buildings to the WSW (247°–263°) with low D/H ratios and small/negative vertical-clearance angles at hub height. These partially mask the WSW sector. In addition, the rooftop plant in the middle of the building creates a local shear/recirculation pocket that partially obstructs the lowest wind speeds arriving across the roof interior; this is visible in the wind-speed rose and explains the muted response for those directions.

Wind power rose shows that  $\approx 70.7\%$  of annual power comes from 180°–270°, with a peak near 210° (S–SSW). In other words, production is driven by southern and SSW flow, not by the obstructed WSW wedge. The recommended installation strip along the south-east edge keeps those high-yield sectors as free as possible while keeping the WSW obstacles largely off-axis.

For installation, place the turbines along the south-east parapet, as close to the parapet as practical to capture the edge speed-up, keeping the lowest rotor lip above the parapet line. Arrange the row with a nominal 1.0 m gap between adjacent bases ( $\approx 2.2$  m center-to-center for 1.2 m bases) and maintain a clear service walkway. This tight spacing prioritises exposure to the S–SSW power sectors while accepting some wake interaction; it keeps the WSW-obstructed wedge largely off-axis and aligns the array with the recommended installation strip shown.



figure 5 - Satellite view [source: geojson.io 2025]

# Wind Speed Analysis

| Monthly Average WindSpeed |                  | Average Windspeed at variable Heights |                  |
|---------------------------|------------------|---------------------------------------|------------------|
| month                     | Mean Speed [m/s] | Height [m]                            | Mean Speed [m/s] |
| Jan                       | 7.97             | 70                                    | 6.50             |
| Feb                       | 8.44             | 75                                    | 6.60             |
| Mar                       | 7.31             | 80                                    | 6.69             |
| Apr                       | 6.69             | 85                                    | 6.78             |
| May                       | 6.26             | 90                                    | 6.86             |
| Jun                       | 6.18             | 95                                    | 6.94             |
| Jul                       | 6.05             | 100                                   | 7.02             |
| Aug                       | 6.01             | 105                                   | 7.09             |
| Sep                       | 6.17             | 110                                   | 7.16             |
| Oct                       | 7.22             | 115                                   | 7.23             |
| Nov                       | 7.19             | 120                                   | 7.29             |
| Dec                       | 7.96             |                                       |                  |

The wind profile at the analyzed location demonstrates consistent wind availability throughout the year, with seasonal variations that follow typical mid-latitude coastal patterns. The highest mean wind speeds occur during the winter months, notably January, February, and December, with averages near 8 m/s, while calmer periods are observed from May through August, averaging around 6.1 m/s. This indicates strong energy potential during colder months when power demand often peaks.

The annual mean wind speed at hub height (95 m) is 6.94 m/s, which reflects favorable conditions for small to medium-scale wind energy applications. The wind profile is stable, with moderate variability across months, providing a reliable basis for year-round operation.

An analysis of wind speeds at different heights reveals a clear vertical wind gradient: from 6.5 m/s at 70 m to approximately 7.3 m/s at 120 m. This confirms that higher installations benefit from stronger and steadier winds, a typical characteristic of urban and peri-urban boundary layers.

# Wind Power Analysis

| Monthly Output |                   |                      |                    |
|----------------|-------------------|----------------------|--------------------|
| month          | Mean Power [Watt] | Monthly Output [kWh] | % of annual output |
| Jan            | 105.08            | 78.18                | 12.80%             |
| Feb            | 120.93            | 82.14                | 13.45%             |
| Mar            | 80.92             | 60.20                | 9.86%              |
| Apr            | 56.70             | 40.82                | 6.68%              |
| May            | 46.86             | 34.86                | 5.71%              |
| Jun            | 44.43             | 31.99                | 5.24%              |
| Jul            | 44.51             | 33.11                | 5.42%              |
| Aug            | 43.47             | 32.34                | 5.29%              |
| Sep            | 50.37             | 36.27                | 5.94%              |
| Oct            | 71.16             | 51.75                | 8.47%              |
| Nov            | 75.55             | 54.40                | 8.91%              |
| Dec            | 100.41            | 74.71                | 12.23%             |

| Output at variable heights |                   |                     |                    |
|----------------------------|-------------------|---------------------|--------------------|
| Height                     | Mean Power [Watt] | Annual Output [kWh] | % of actual output |
| 70                         | 57.3              | 492.87              | 82.44%             |
| 75                         | 59.8              | 514.94              | 86.13%             |
| 80                         | 62.3              | 536.41              | 89.72%             |
| 85                         | 64.8              | 557.37              | 93.23%             |
| 90                         | 67.2              | 577.84              | 96.65%             |
| 95                         | 69.5              | 597.86              | 100.00%            |
| 100                        | 71.8              | 617.44              | 103.28%            |
| 105                        | 74.0              | 636.63              | 106.48%            |
| 110                        | 76.2              | 655.44              | 109.63%            |
| 115                        | 78.3              | 673.91              | 112.72%            |
| 120                        | 80.4              | 692.06              | 115.76%            |

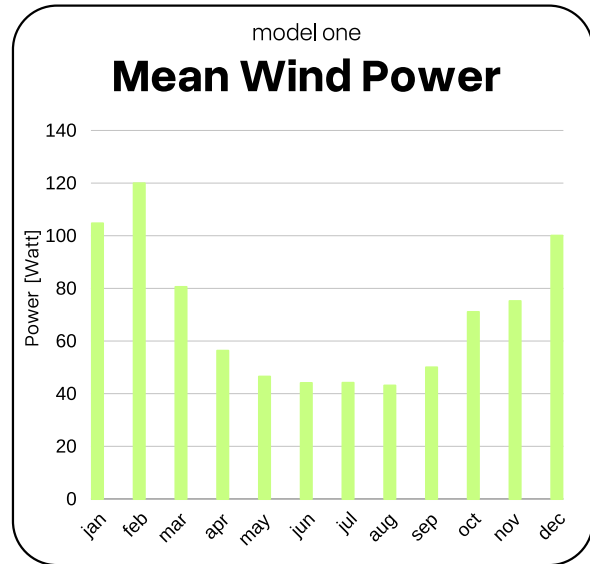
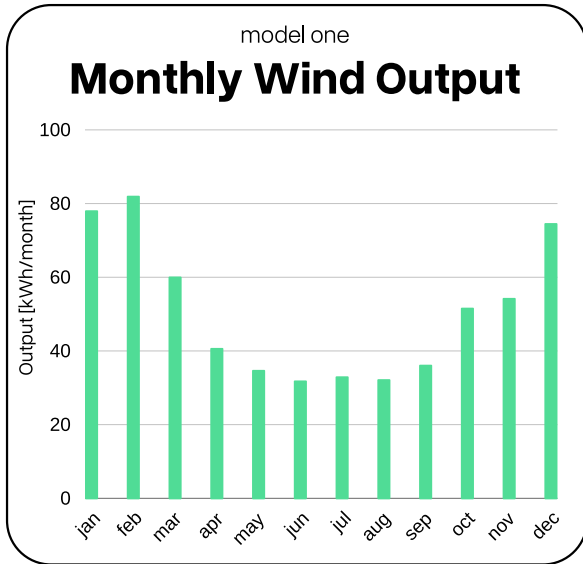
# Wind Power Analysis

The energy output distribution closely follows the seasonal wind behavior observed earlier, with higher production during winter months. January and February deliver the strongest performance, together accounting for nearly 27% of total annual output, while the calmer summer period from May to August contributes less than 20%. Despite these variations, the turbine maintains steady generation throughout the year, producing around 598 kWh annually from wind for Model One at a 95-meter hub height, and 698 kWh including solar energy.

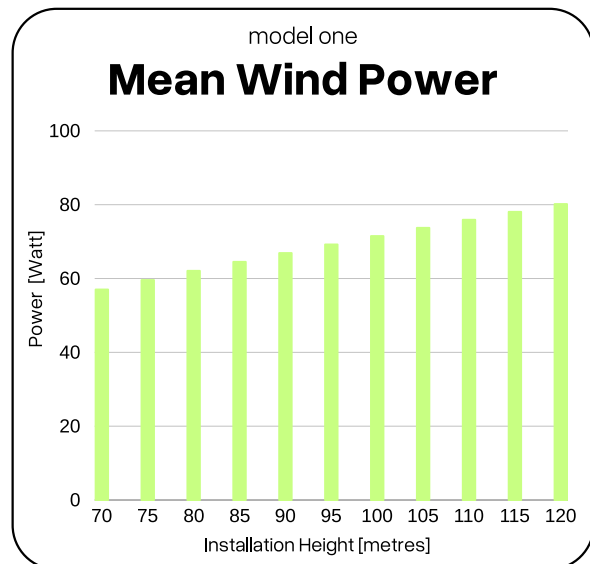
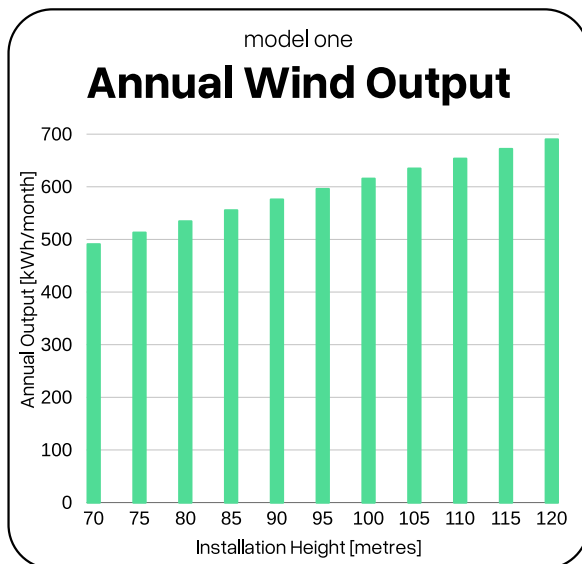
When comparing turbine performance at different heights, output increases predictably with altitude. Wind Power generation rises from roughly 493 kWh at 70 meters to over 692 kWh at 120 meters, a 40% gain in yield. This highlights the strong influence of height on wind power potential, especially relevant for optimizing design and placement.

Overall, the site provides a stable, productive wind resource that suits small-scale distributed systems like the Airturb Model One. The consistent relationship between height, wind strength, and energy yield offers clear guidance for maximizing output and ensuring strong long-term performance.

# Wind Power Analysis



The calculated results were converted into these graphs to visualize seasonal variation in power generation. Model One produces 597.86 kWh yearly from wind, while the integrated solar panels contribute an additional 100 kWh on average, bringing the total output to 697.86 kWh.



The graphs illustrate how wind output increases with installation height, showing greater energy potential at higher elevations. Mean wind power rises from 57.3 W at 70 m to 80.43 W at 120 m, while annual wind output grows from 492.87 kWh to 692.06 kWh. These figures exclude the additional 100 kWh from solar panels, which further enhances yearly production potential.

# Comparative Wind Analysis

| Zuid Holland Wind Conditions |                 |                          |
|------------------------------|-----------------|--------------------------|
| Height                       | Windspeed [m/s] | Annual Wind Output [kWh] |
| 70m                          | 7.39            | 734.6                    |
| 75m                          | 7.50            | 769.19                   |
| 80m                          | 7.61            | 803.02                   |
| 85m                          | 7.81            | 836.13                   |
| 90m                          | 7.81            | 868.64                   |
| 95m                          | 7.91            | 900.51                   |
| 100m                         | 8.00            | 931.86                   |

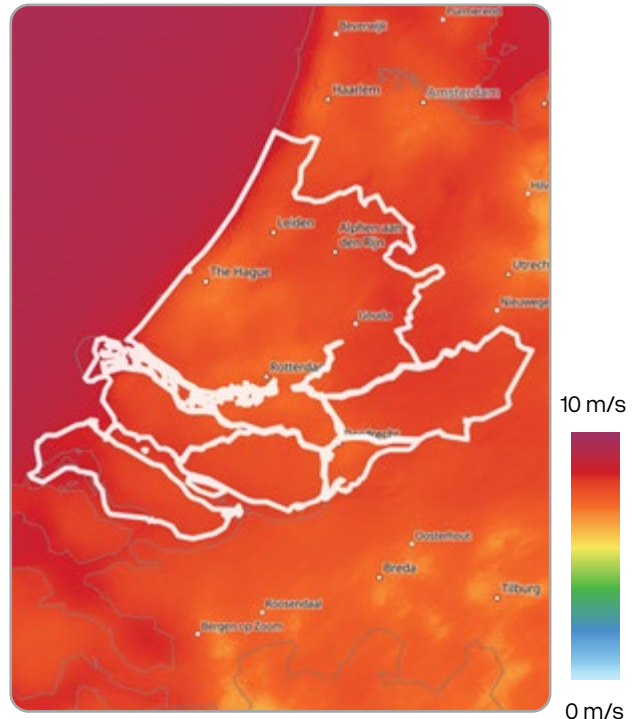


figure 6 - Windspeeds 100m Zuid-Holland [source: globalwindatlas 2025]

When comparing the site-specific results from Hofplein to the regional wind conditions of Zuid-Holland, a clear pattern emerges. The measured wind speeds at Hofplein are slightly lower than the regional averages, with a mean speed of 6.9 m/s at 95 meters, compared to the regional average of 7.9 m/s. This difference translates to an estimated output reduction of around 40%, which aligns with expectations for a densely built urban environment.

The Hofplein location, situated in the city center of Rotterdam, is influenced by urban wind dynamics such as turbulence, wake effects, and increased surface roughness caused by surrounding buildings. These factors typically reduce average wind speeds but can also create localized acceleration zones that intermittently enhance turbine performance.

Despite the expected urban losses, the analyzed site still shows consistent and predictable wind behavior, confirming its potential for small-scale distributed generation.

# Carbon Reduction

| Field  | Value   | Amount | Total          |
|--|---------|--------|----------------|
| Annual Energy [kWh/yr]                         | 697.86  | 10     | 6978.60        |
| Grid Emission Factor [kg CO <sub>2</sub> /kWh] | 0.4     |        |                |
| Model One Emission [kg CO <sub>2</sub> /kWh]   | 0       | 10     | 0.00           |
| <b>CO<sub>2</sub> Avoided [kg/yr]</b>          | 279.144 | 10     | <b>2791.44</b> |
| <b>CO<sub>2</sub> Avoided [tonnes/yr]</b>      | 0.28    | 10     | <b>2.79</b>    |

All carbon emissions that occur during the production of the Airturb Model One are compensated through certified tree planting initiatives. The environmental impact of each installation is further quantified by comparing its annual energy production to the average Dutch grid emission factor.

Each turbine produces approximately 697.86 kWh per year, offsetting around 280 kilograms of CO<sub>2</sub> annually, equivalent to about 2.8 tonnes for a 10-unit installation.

These figures are based on the current average grid intensity of 0.4 kg CO<sub>2</sub> per kWh (source: European Environment Agency, 2025). As the national grid continues to decarbonize, these avoided emissions will proportionally decrease over time.

Beyond measurable impact, the Airturb Model One visually reflects a company's sustainability mission. The visible presence of on-site renewable energy reinforces environmental responsibility and helps inspire positive behavioral change toward sustainability among employees, visitors, and the surrounding community.

# Economics

| Field                              | Value          | Amount | Total      |
|------------------------------------|----------------|--------|------------|
| CapEx [EUR]                        | 3,500.00€      | 10     | 35,000.00€ |
| O&M fraction 2%                    | 0.02           |        |            |
| O&M [EUR/yr]                       | 70.00€         | 10     | 700.00€    |
| Discount rate                      | 0.03           |        |            |
| Lifetime [years]                   | 20             |        |            |
| Capital Recovery Factor            | 0.067          |        |            |
| Annualized CapEx [EUR/yr]          | 235.25€        | 10     | 2,352.55€  |
| Annual Energy [kWh/yr, normalized] | 697.86         | 10     | 6,978.60   |
| Energy Price [EUR/kWh]             | 0.35€          |        |            |
| <b>Energy Savings</b>              | <b>244.25€</b> |        |            |
| <b>ROI [years]</b>                 | <b>14.33</b>   |        |            |
| <b>LCOE [EUR/kWh]</b>              | <b>0.44€</b>   |        |            |

We evaluate the financial performance of the Airturb Model One based on its investment and operational parameters. With a capital expenditure of €3,500 and an annual O&M cost of 2% of CapEx, the model assumes a 3% discount rate and a 20-year operational lifetime. This results in a Capital Recovery Factor (CRF) of 0.067, corresponding to an annualized CapEx of approximately €235 per unit.

Combining this with the expected normalized annual energy output of 697.86 kWh per turbine, the Levelized Cost of Energy (LCOE) is calculated at €0.44 per kWh. This reflects the current small-scale production cost and serves as a reference for assessing economic viability at different deployment scales or cost-reduction scenarios.

# Comparative Economics

| Config uration | Amount | Unit Price | CapEx       | Annual Output [kWh] | Yearly Energy Savings | LCoE   | ROI [years] |
|----------------|--------|------------|-------------|---------------------|-----------------------|--------|-------------|
| Core           | 1      | 3,400.00€  | 3,400.00€   | 597.86              | 209.25€               | 0.496€ | 16.25       |
| Core           | 10     | 2,644.44€  | 26,444.40€  | 5978.6              | 2,092.51€             | 0.385€ | 12.64       |
| Core           | 100    | 2,077.78€  | 207,778.00€ | 59786               | 20,925.10€            | 0.303€ | 9.93        |
| Base           | 1      | 4,100.00€  | 4,100.00€   | 597.86              | 209.25€               | 0.598€ | 19.59       |
| Base           | 10     | 3,188.89€  | 31,888.90€  | 5978.6              | 2,092.51€             | 0.465€ | 15.24       |
| Base           | 100    | 2,505.56€  | 250,556.00€ | 59786               | 20,925.10€            | 0.365€ | 11.97       |
| Solar          | 1      | 4,500.00€  | 4,500.00€   | 697.86              | 244.25€               | 0.562€ | 18.42       |
| Solar          | 10     | 3,500.00€  | 35,000.00€  | 6978.6              | 2,442.51€             | 0.437€ | 14.33       |
| Solar          | 100    | 2,750.00€  | 275,000.00€ | 69786               | 24,425.10€            | 0.343€ | 11.26       |
| Sky            | 1      | 5,600.00€  | 5,600.00€   | 597.86              | 209.25€               | 0.816€ | 26.76       |
| Sky            | 10     | 4,355.56€  | 43,555.60€  | 5978.6              | 2,092.51€             | 0.635€ | 20.82       |
| Sky            | 100    | 3,422.22€  | 342,222.00€ | 59786               | 20,925.10€            | 0.499€ | 16.35       |



# Conclusions

The Hofplein 20 site shows a stable urban wind resource with a hub-height mean wind speed of 6.94 m/s at 95 m and dominant S–SSW sectors. Model One yields ~597.9 kWh/yr from wind, rising predictably with height ( $\approx 493$  kWh at 70 m to  $\approx 692$  kWh at 120 m). With the integrated solar base, total annual output is ~697.9 kWh. Directional roses and obstacle mapping confirm siting along the south-east parapet to keep high-yield sectors clear while avoiding the WSW obstacles.

Economically, using €0.35/kWh and CapEx €3,500, the annualized CapEx is ~€235 (CRF = 0.067), the illustrative LCOE  $\approx$  €0.44/kWh, and simple ROI  $\approx$  14.3 years for the solar-integrated option. Environmental co-benefits are material: ~0.28 t CO<sub>2</sub> avoided per unit per year at today's grid intensity. Overall, the site supports a small, visible, and reliable deployment of Model One.

Beyond direct kWh savings and CO<sub>2</sub> reductions, the installation functions as visible sustainability signage, strengthening brand credibility, supporting ESG disclosures, engaging employees and visitors, and nudging public behavior toward cleaner choices.



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Signature

Signature

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29 October 2025

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31 October 2025

| Version | Author               | Date             | Remarks/Change                                   |
|---------|----------------------|------------------|--|
| 1.0     | J.M. van Wijngaarden | 13 October       | Draft for client review                          |
| 2.0     | J.M. van Wijngaarden | 24 October 2025  | Final for client review                          |
| 3.0     | J.M. van Wijngaarden | 31 October       | Final; Published                                 |
| 4.0     | J.M. van Wijngaarden | 20 november 2025 | Textual changes related to certification process |

# A. Figures and Visual References

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|          |  |                        |
|----------|--|------------------------|
| Figure 1 | Hofplein 20, Rotterdam – Site view from Hofplein 20 showing the installation surroundings. | <a href="#">Source</a> |
| Figure 2 | Building heights – Building elevation data for the Hofplein area.                          | <a href="#">Source</a> |
| Figure 3 | Top view – Location and exposure of the site visualized using coordinate-based mapping.    | <a href="#">Source</a> |
| Figure 4 | Wind Roses – Frequency, speed, and power distribution by direction.                        | <a href="#">Source</a> |
| Figure 5 | Satellite view – Overview of site terrain, nearby obstacles, and surrounding surfaces.     | <a href="#">Source</a> |
| Figure 6 | Windspeeds 100m Zuid-Holland – Mean Windspeeds   | <a href="#">Source</a> |

All figures included in this document were compiled on 13 October, 2025.

## B. Data and Sources

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The analysis presented in this report is based on ERA5–Land reanalysis data from the European Centre for Medium–Range Weather Forecasts (ECMWF), as described in the Methodology & Data Sources section (see page 5).

The dataset spans January 2016 – October 2025 with hourly resolution and a  $0.25^\circ \times 0.25^\circ$  spatial grid.

All data were processed through Airturb’s internal assessment framework, which standardizes ERA5–derived parameters into height–adjusted, site–specific wind conditions.

# C. Configurations



## Core

Basic power generation module, suitable for integration into existing infrastructure.

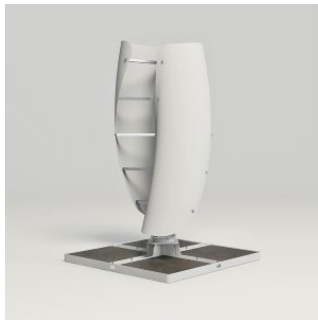
Height: 1820 mm  
Width: 780 mmm



## Sky

Elevated configuration on a 4 metre pole for improved wind capture.

Height: 5820 mm  
Width: 780 mmm



## Base

Ideal for flat surfaces or rooftop installations. Includes a low, compact base structure, that incorporates 4 concrete tiles as counterweight.

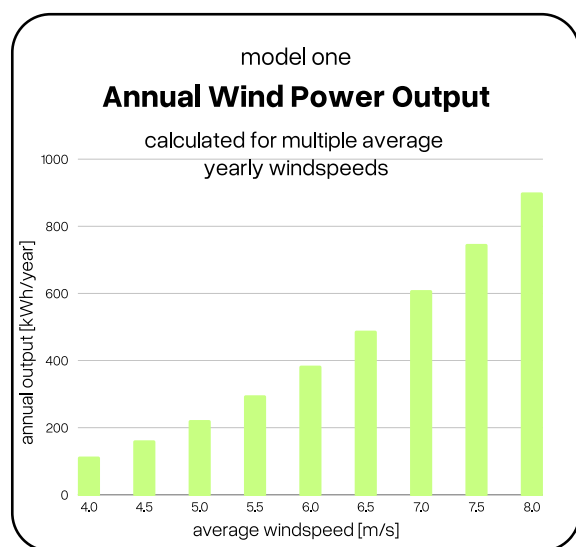
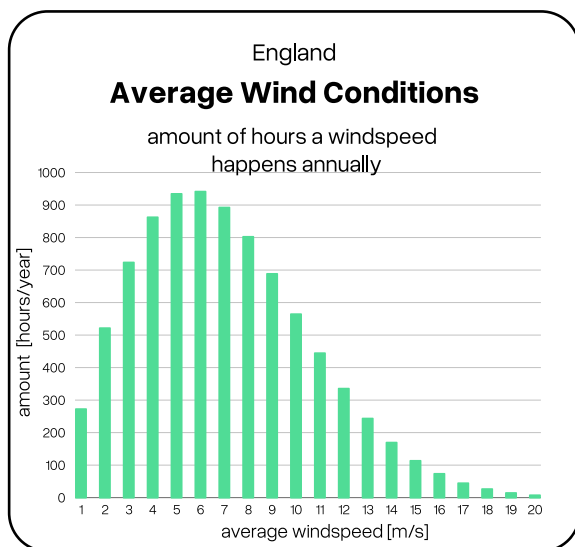
Height: 2040 mm  
Width: 1140 mmm



## Solar

Base option with added solar panels, for more balanced year round energy output.

Height: 2040 mm  
Width: 1140 mmm



*\*excluding annual average of 100 kWh solar output\**



## D. Glossary of Key Terms

|                          |   |
|--------------------------|---|
| ERA5                     | ECMWF's global atmospheric reanalysis dataset   |
| C <sub>p</sub>           | Power coefficient, efficiency of wind energy extraction   |
| z <sub>0</sub>           | Roughness length (surface aerodynamic property)   |
| d                        | Displacement height (accounts for building height)  |
| ρ                        | Air density (kg/m <sup>3</sup> )  |
| CRF                      | Capital Recovery Factor   |
| LCoE                     | Levelized Cost of Energy (€ per kWh)  |
| Weibull k                | Shape factor of wind speed distribution   |
| Weibull c                | Scale factor of wind speed distribution   |
| AEP                      | Annual Energy Production (kWh/year)   |
| Hub height               | Height of the turbine's central rotor axis above the ground.  |
| Wind rose                | Circular diagram showing how often the wind blows from each direction.  |
| Turbulence               | Irregular or fluctuating air motion that affects wind turbine performance.  |
| Uncertainty band         | The estimated range within which the real energy output is likely to fall, based on modeling uncertainty.               |
| Wind index normalization | A method to compare measured data to long-term averages for accuracy and consistency.                                   |
| Savonius turbine         | A type of vertical-axis wind turbine that captures wind from all directions and performs well in turbulent urban flows. |
| Cut-in speed             | The minimum wind speed required for the turbine to start generating electricity.  |
| Horizontal-axis turbine  | A conventional turbine design with blades that rotate around a horizontal axis, facing the wind.                        |

## D. Glossary of Key Terms

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|                           |  |
|---------------------------|--|
| Reanalysis data           | A processed dataset that combines observations and weather models to estimate past atmospheric conditions.               |
| Surface roughness         | The texture of the ground and buildings that affects how wind flows near the surface.                                    |
| Exposure correction       | Adjustments to account for the influence of buildings or terrain on measured wind speeds.                                |
| Height-sensitivity curve  | A graph showing how wind speed or energy output changes with installation height.  |
| Wind shear                | The change in wind speed with height, often stronger in cities than open areas.  |
| CO <sub>2</sub> avoidance | The estimated reduction in carbon dioxide emissions achieved by producing clean wind energy instead of grid electricity. |

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max. solar power 120W

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Rooftop & pole

rotor surface  
1m<sup>2</sup>



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