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# ENVIRONMENTAL ASSESSMENT

## Newcastle Gas Storage Facility Project

**Major Project Application Number 10-0133**

## Volume 5: Appendices 14 – 16

**May 2011**

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# ENVIRONMENTAL ASSESSMENT

## Newcastle Gas Storage Facility Project

Major Project Application Number 10-0133

**Volume 5: Appendices 14 – 16**

May 2011

CR 6023_8_v3

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| **Version:** | **Details:** | **Approved:** | **Date:** |
| CR 6023_8_v1 | Initial draft to client | CB | 14/02/2011 |
| CR 6023_8_v2 | Second draft to client and Department of Planning | CB | 24/02/2011 |
| CR 6023_8_v3 | Final to client | CB | 23/05/2011 |

# Appendix 15

**Plume Rise Assessment**

REPORT - FINAL

# PLUME RISE ASSESSMENT – NEWCASTLE GAS STORAGE FACILITY

AGL Energy Limited

**Job No:** **3872**

**25 March 2011**

A PEL Company

| | |
|---|---|
| **PROJECT TITLE:** | **PLUME RISE ASSESSMENT – NEWCASTLE GAS STORAGE FACILITY** |
| **JOB NUMBER:** | **3872** |
| **PREPARED FOR:** | Arianna Henty |
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# 1 INTRODUCTION

PAEHolmes has been commissioned by AGL Energy Limited to undertake plume rise modelling and assessment for the proposed Newcastle Gas Storage Facility (NGSF). The proposed NGSF is located at Tomago, New South Wales, approximately 10 km north of Newcastle and 10 km west of Newcastle Airport. Due to the proximity of the NGSF to the airport, a plume rise assessment is required to assess the potential impact from exhaust plumes on aviation safety.

Aviation authorities have established that exhaust plumes with vertical velocity exceeding 4.3 metres per second (m/s) may cause damage to an aircraft airframe, or upset an aircraft flying at low levels. Guidelines for plume rise assessment have been developed by the Civil Aviation Safety Authority (CASA) (**CASA, 2004**) and require that facilities where the vertical velocity of exhaust plumes exceed 4.3 m/s at the aerodrome Obstacle Limitation Surface (OLS) (or 110 m above ground level anywhere) must undertake plume rise modelling to assess the potential hazard to aircraft operations.

As Newcastle Airport is also a Royal Australian Air Force (RAAF) Base, the plume rise assessment would also be reviewed by the Department of Defence (DoD), having regard to their Obstruction Clearance Surfaces (OCS).

The purpose of this report is to assess the potential impact of exhaust plumes from emission sources at the NGSF, for comparison against the OLS / OCS of Newcastle Airport.

# 2 PROJECT OVERVIEW

The proposed NGSF will consist of a processing plant which will convert pipeline natural gas to Liquefied Natural Gas (LNG) by cooling it to -162°C. It will be capable of processing up to 65,500 tonnes of LNG per year which would be stored in an insulated non-pressurised LNG storage tank capable of containing 30,000 tonnes or 63,000 $m^3$ of LNG.

A re-gasification unit would be used to convert the LNG in the storage tank back into natural gas as required for supply. A flare stack would be used to burn sour gas (removed during gas sweetening) and flare excess hydrocarbons.

There are four emissions sources considered for this plume rise assessment, as follows:

- Hot oil heater at liquefaction plant;
- 2 x LNG vaporiser packages (for re-gasification); and
- Flare stack.

The vapouriser unit would not be operational when the plant is in liquefaction mode and therefore there would be no potential for buoyancy enhancement from these sources.

There are four scenarios under which the flare stack would operate:

- Normal operations (process flare pilot only);
- Flaring of the sour gas during liquefaction;
- Flaring during start-up / shut-down; and
- Flaring of gas during an emergency.

A conceptual plant layout is presented in **Figure 2.1** showing emission points at the flare, the liquefaction plant and the re-gasification units.

The location of the site in relation to Newcastle Airport is shown in **Figure 2.2**.

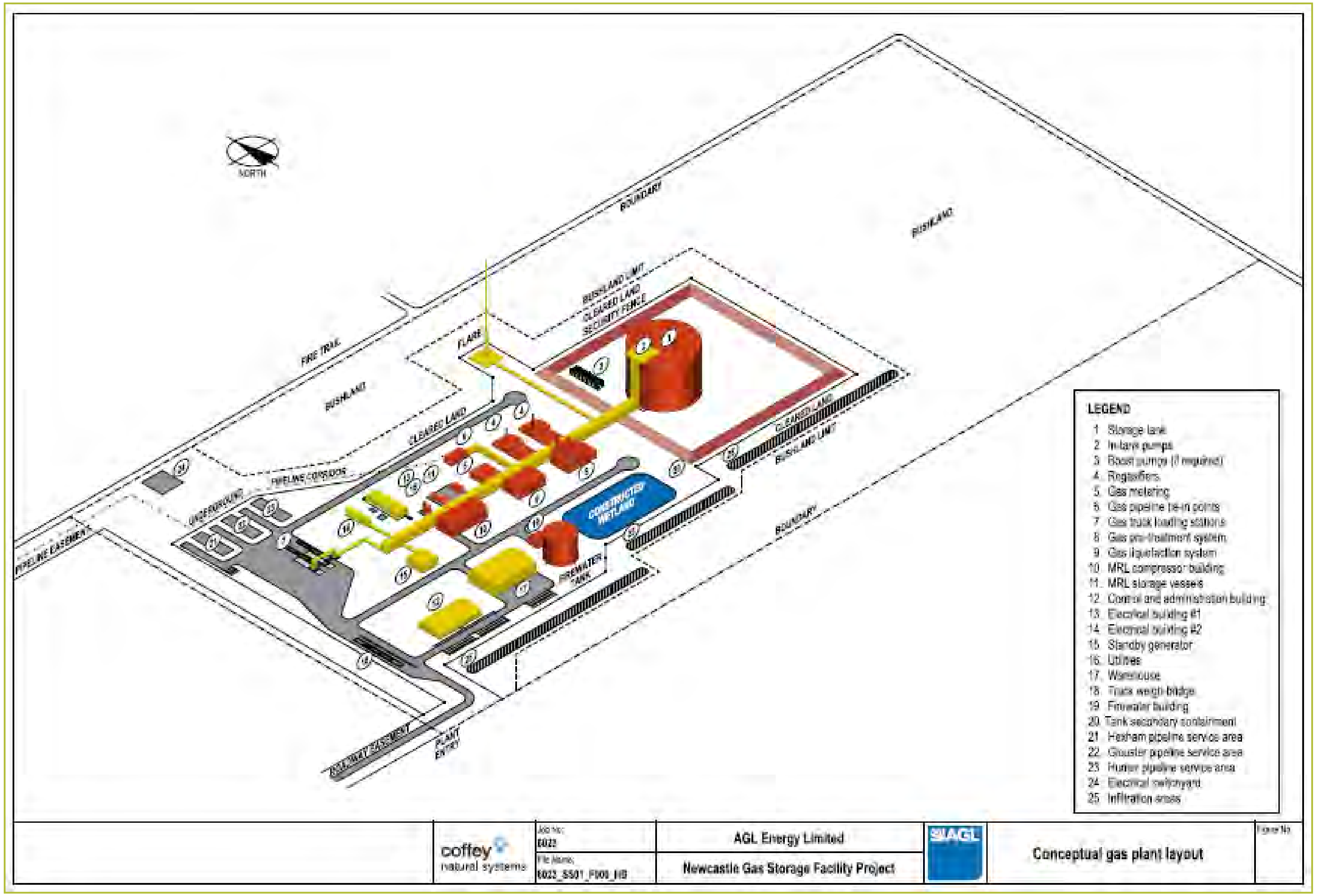


**Figure 2.1: Concept Site Layout and Emissions Points**

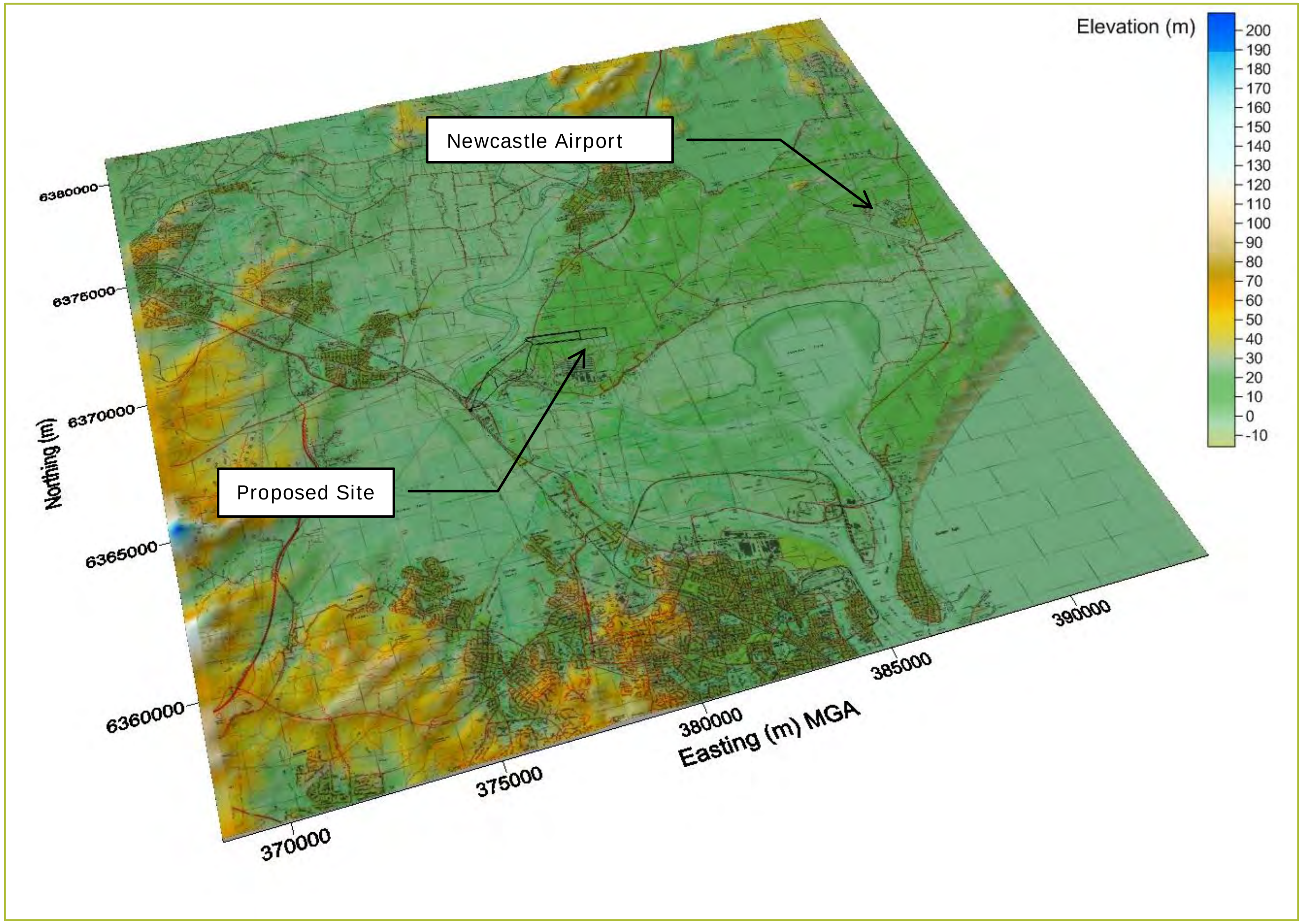


**Figure 2.2 Regional Setting and Location of Site**

# 3 STUDY REQUIREMENTS

Aviation authorities have established that exhaust plumes with vertical velocity exceeding 4.3 metres per second (m/s) may cause damage to an aircraft airframe, or upset an aircraft flying at low levels. CASA have subsequently required that proponents of a facility where the vertical velocity of exhaust plumes exceed 4.3 m/s (at the aerodrome Obstacle Limitation Surface (OLS) or 110 m above ground level anywhere) must undertake plume rise modelling to assess the potential hazard to aircraft operations.

Requirements for plume rise assessment are outlined in CASA's Advisory Circular titled *Guidelines for Conducting Plume Rise Assessment* (**CASA, 2004**).

The following summarises the requirements of CASA when plume rise modelling and assessment is conducted:

- Modelling using The Air Pollution Model (TAPM) version 2.0 or higher;
- At least five years of continuous meteorological data modelled;
- Horizontal displacement of the plume centreline evaluated as a function of height;
- Plume spread about the centreline evaluated as a function of height;
- Consideration of "average" and "peak" vertical plume velocities for each height;
- Wind speed evaluated as a function of height; and
- Probability of vertical velocity exceeding 4.3 m/s.

TAPM v.4 has been run in accordance with the CASA requirements. The modelling approach as well as a summary of results is provided in the following two sections.

# 4 APPROACH TO ASSESSMENT

In accordance with CASA requirements, TAPM was run for a five year modelling period (2006 to 2010 inclusive). No local meteorology was assimilated into the model. The model was run in the combined meteorology and pollution mode with multiple sources representing exhaust plumes from each emission point at the site. **Table 4.1** summarises the TAPM user inputs and settings.

**Table 4.1 : Summary of TAPM modelling parameters**

| TAPM | Version 4.0 |
|---|---|
| Number of grids (spacing) | 3 (30 km, 10 km, 3 km) |
| Number of grids point | 25 x 25 x 25 |
| Year of analysis | Jan 2006 to Dec 2010 |
| Terrain information | AUSLIG 9 second DEM data |
| Centre of analysis | 33° 49' 30" S, 151° 43' E (MGA Zone 56 380276 m, 6367552 m) |
| Mode | Meteorology and Pollution mode |

Stack parameters for the hot oil heater and vaporisation package stacks are shown in **Table 4.2**. The flare can potentially operate under four different scenarios, and the modelled stack parameters for these scenarios are presented in **Table 4.3**. The modelled stack parameters for the flare are adjusted to account for additional release height of the flame. For example, the actual stack height (30m) is adjusted (to account for flame height) to determine the effective release height for the initial point of plume rise. Similarly, the stack diameter is adjusted to an equivalent release diameter.

As the effective release height is dependent on the total heat release rate, which is in turn governed by the volume of gas flow to the flare, different stack parameters are modelled for the different operational scenarios. For example, during an emergency when the plant is depressurised to flare and gas flow is high, the flame height will be at its maximum. The effective stack height and diameters have been derived using the Alberta Environment's flare calculation spreadsheet (**Alberta Government, Canada (2010)**).

The hot oil heater stack has a exit velocity of less than 4.3 m/s (0.7 m/s) and is therefore not considered further. Similarly, normal operation of the flare would involve a pilot flare with minimal assist gas flow. The exit velocity under this scenario is estimated to be very low and less than 4.3 m/s (based on calculations of gas flow) and is therefore not considered further.

For other flare operating scenarios, the effective exit velocity is set to 20 m/s and the effective exit temperature is set to 1273 K, in accordance with typical approaches for modelling flare emissions.

**Table 4.2 : Liquefaction and vaporisation stack parameters**

| Source | Hot oil heater | Vaporisation 1 | Vaporisation 2 |
|---|---|---|---|
| Stack easting MGA (m) | 381151 | 381137 | 381162 |
| Stack northing MGA (m) | 6368752 | 6368790 | 6368787 |
| Base Elevation (m) | 17 | 16 - 17 | 16 - 17 |
| Stack Height (m) | 15 | 10 | 10 |
| Stack Diameter (m) | 1 | 1 | 1 |
| Temperature (K) | 593 | 313 | 313 |
| Exit Velocity (m/s) | 0.9 | 8.3 | 8.3 |
| Volumetric Flow ($Am^3/s$) | 0.7 | 6.52 | 6.52 |

**Table 4.3 : Flare parameters**

| Source | Normal | Sour gas flare | Start-up / Shut down | Emergency |
|---|---|---|---|---|
| Stack easting MGA (m) | 381210 | 381210 | 381210 | 381210 |
| Stack northing MGA (m) | 6368871 | 6368871 | 6368871 | 6368871 |
| Base Elevation (m) | 17 | 17 | 17 | 17 |
| Effective Stack Height (m) | 32.2 | 31.8 | 43.2 | 70.2 |
| Effective Diameter (m) | 1.9 | 0.719 | 1.9 | 1.9 |
| Temperature (K) | 1273 | 1273 | 1273 | 1273 |
| Exit Velocity (m/s) | 0.3 | 20 | 20 | 20 |
| Volumetric Flow ($Am^3/s$) | 0.01 | 0.22 | 2.0 | 20.6 |

# 5 MODEL RESULTS

TAPM output from the five year simulation period includes a file containing gradual plume rise data for every hour for each of the modelled scenarios. Gradual plume rise data provides information on in-plume vertical velocity, plume height above ground and plume dimensions from the time of release to time of final plume height. Statistics were generated from this data file by interpolating to selected heights above ground and are analysed for each scenario in the following sections.

## 5.1 Flare scenarios

### 5.1.1 Sour gas

A sample of the gradual plume rise output file from TAPM is presented below. The sample file shows plume rise outputs for the first five seconds (t(s)) after release, for the first two hours of 2006. The outputs show the vertical velocity (w), height above ground (z) and plume spread statistics (Ry, Rz, Dx and Dy).

| DATE=20060101 | HOUR= 1 | | | | | | |
|---|---|---|---|---|---|---|---|
| src# | t(s) | w(m/s) | z(m) | Ry(m) | Rz(m) | Dx(m) | Dy(m) |
| 3 | 1 | 1.27 | 37 | 2 | 1 | 1 | -4 |
| 3 | 2 | 1.18 | 38 | 3 | 2 | 1 | -8 |
| 3 | 3 | 1.09 | 39 | 4 | 2 | 2 | -12 |
| 3 | 4 | 1.01 | 41 | 4 | 2 | 3 | -16 |
| 3 | 5 | 0.95 | 41 | 5 | 2 | 4 | -21 |
| DATE=20060101 | HOUR= 2 | | | | | | |
| 3 | 1 | 1.23 | 37 | 2 | 1 | 1 | -4 |
| 3 | 2 | 1.15 | 38 | 3 | 1 | 2 | -8 |
| 3 | 3 | 1.07 | 39 | 4 | 2 | 2 | -13 |
| 3 | 4 | 0.99 | 40 | 4 | 2 | 3 | -17 |
| 3 | 5 | 0.94 | 41 | 5 | 2 | 4 | -22 |

The first data point for the gradual plume rise is provided 1 second after release and corresponds to the lowest height above the release at which TAPM can resolve plume rise data. For the sour gas scenario this height was, on average, 37 m, although the plume heights for each time step can differ for each hour of the simulation. As such, plume rise statistics for specific heights need to be interpolated from the TAPM outputs.

The average vertical velocity after 1 second is 1.4 m/s and the maximum vertical velocity is 2.5 m/s. In other words, the vertical velocity of the plume falls below 4.3 m/s within 1 second and the only assumption that can be made for this scenario is that the height at which the plume average vertical velocity falls below 4.3 m/s is 37 m above ground level or approximately 54 m AHD.

CASA's Guidelines for Conducting Plume Rise Assessment require detailed analysis of plume development, including for example, heights above the ground at which the average vertical velocity of the plume exceeds the critical vertical velocity (4.3 m/s) for the following percentages of time: 100%, 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, 0.3%, 0.2%, 0.1%, 0.05%. These data need to be interpolated from the TAPM output, however, it is clear from the results that this interpolation is not possible in this case.

In summary, at the release height of 32 m (49 m AHD) the critical vertical velocity is exceeded 100% of the time and after 1 second, at 37 m (54 m AHD) it is exceeded 0% of the time.

### 5.1.2 Start up / Shut down

Plume rise statistics for specific heights for the start up / shut down scenario have been interpolated from the TAPM outputs. **Table 5.1** summarises the average and maximum horizontal displacement of the centreline and plume spread about the centreline and the corresponding maximum average in-plume vertical velocity of the plume when operating under start-up / shut down conditions.

**Table 5.1: TAPM simulated plume rise statistics for start-up / shut down**

| Height above local ground-level (m) | Maximum vertical velocity (m/s) | Average vertical velocity (m/s) | Average plume spread about centreline (m) | Maximum plume spread about centreline (m) | Average horizontal displacement from source (m) | Maximum horizontal displacement from source (m) |
|---|---|---|---|---|---|---|
| Lowest (ave 49) | 5.1 | 2.8 | 4.0 | 4.0 | 3.8 | 14.9 |
| 52 | 5.0 | 2.5 | 5.6 | 6.0 | 8.4 | 58.3 |
| 60 | 5.5 | 1.9 | 9.8 | 11.0 | 26.0 | 123.0 |
| 70 | 5.4 | 1.5 | 15.2 | 17.0 | 55.1 | 241.5 |
| 80 | 5.1 | 1.3 | 20.4 | 23.0 | 91.5 | 384.2 |
| 90 | 4.8 | 1.1 | 25.5 | 29.0 | 134.8 | 579.4 |
| 100 | 4.6 | 1.0 | 30.6 | 36.0 | 185.9 | 807.6 |
| 120 | 4.2 | 0.8 | 40.9 | 53.0 | 304.9 | 1341.0 |
| 150 | 3.8 | 0.7 | 56.1 | 83.0 | 468.6 | 1862.1 |
| 200 | 3.3 | 0.6 | 82.1 | 167.0 | 797.8 | 2316.9 |
| 400 | 2.2 | 1.0 | 128.1 | 186.0 | 168.8 | 443.0 |
| 600 | 1.7 | 1.2 | 132.8 | 155.0 | 72.1 | 136.0 |

These data are also presented graphically in **Figure 5.1** showing a two-dimensional view of the plume development from the point of release for the start-up / shutdown scenario. The maximum lateral cross-wind spread of the plume has been projected on to the x direction. This figure allows the regions of space where the maximum average in-plume vertical velocity exceeds 4.3 m/s to be determined.

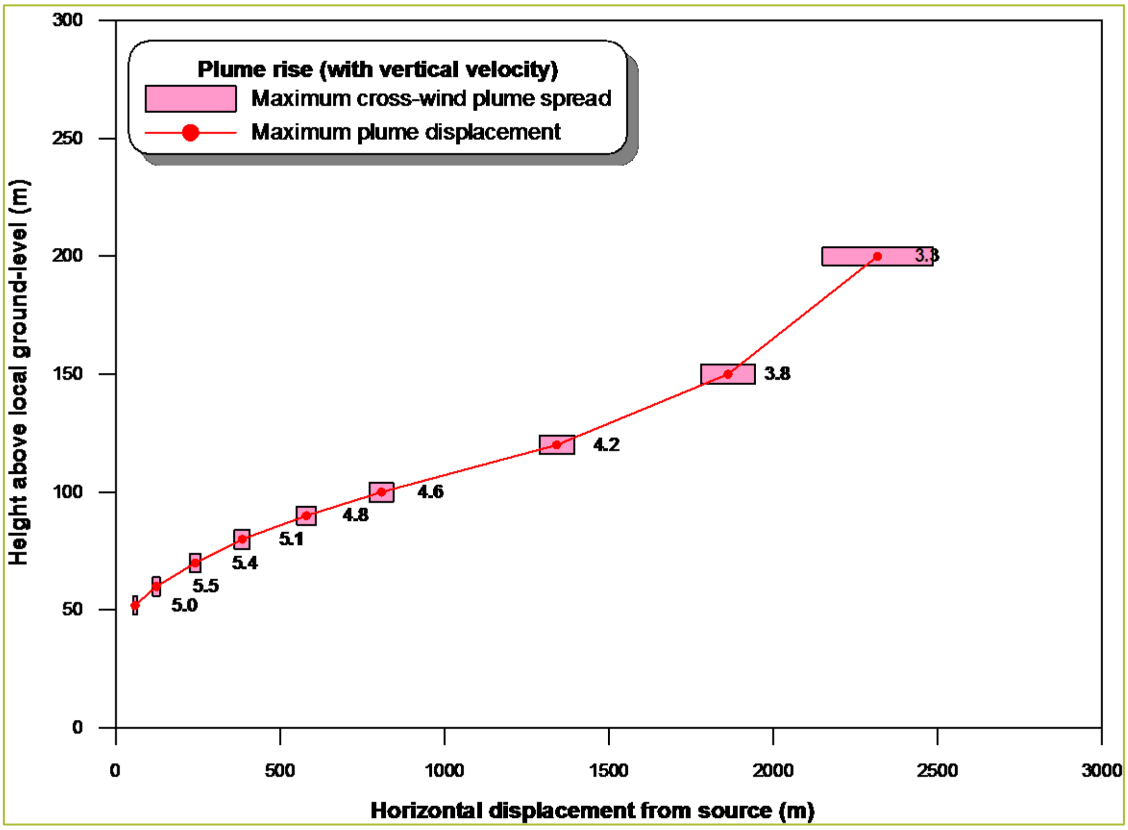


**Figure 5.1: Plume development – Start up / Shut down**

CASA require information on the heights above the ground at which the average vertical velocity of the plume exceeds the critical vertical velocity (4.3 m/s) for various percentages of time. However, as discussed in **Section 5.1.1**, plume rise drops off rapidly and TAPM output cannot be interpolated for predictions that occur within 1 second of the plume being released. **Table 5.2** shows the heights above ground where the average vertical velocity exceeds 4.3 m/s for selected percentiles where data is able to be interpolated. These results suggest that the probability of the maximum average in-plume vertical velocity exceeding 4.3 m/s at say, 70 m (87 m AHD), is approximately 0.2%.

However, it is also important to note that the way the start up / shut down is modelled has to assume this scenarios is continuous. In reality, the frequency of occurrence of start up / shut down events would be limited to approximately 12 per year, with an expected duration of 48 hours per event. On this basis, the start up / shut down event would occur for just 6 % of the year and the percentage frequency of exceedance in **Table 5.2** only applied to 6 % of the time.

**Table 5.2: Percentage of time that maximum vertical velocity exceeds 4.3 m/s**

| Frequency of exceedance of 4.3 m/s (%) | Height above ground level (m) | Height above sea level (m AHD) |
|---|---|---|
| 100 | 43 | 60 |
| 1 | 56 | 73 |
| 0.5 | 62 | 79 |
| 0.3 | 67 | 84 |
| 0.2 | 70 | 87 |
| 0.1 | 80 | 97 |
| 0.05 | 86 | 103 |

### 5.1.3 Emergency

Plume rise statistics for specific heights for the emergency scenario have been interpolated from the TAPM outputs. **Table 5.3** summarises the average and maximum horizontal displacement of the centreline and plume spread about the centreline and the corresponding maximum average in-plume vertical velocity of the plume in an emergency.

**Table 5.3: TAPM simulated plume rise statistics for Emergency Scenario**

| Height above local ground-level (m) | Maximum vertical velocity (m/s) | Average vertical velocity (m/s) | Average plume spread about centreline (m) | Maximum plume spread about centreline (m) | Average horizontal displacement from source (m) | Maximum horizontal displacement from source (m) |
|---|---|---|---|---|---|---|
| Lowest (ave 76) | 5.1 | 2.6 | 4.0 | 4.0 | 4.6 | 15.8 |
| 80 | 5.1 | 2.2 | 6.2 | 7.0 | 13.2 | 79.8 |
| 85 | 5.5 | 1.9 | 8.9 | 10.0 | 26.7 | 110.1 |
| 90 | 5.5 | 1.6 | 11.7 | 13.0 | 42.8 | 181.1 |
| 100 | 5.3 | 1.3 | 16.9 | 18.0 | 82.0 | 329.6 |
| 110 | 5.0 | 1.1 | 22.3 | 25.0 | 129.8 | 522.9 |
| 120 | 4.7 | 1.0 | 27.6 | 31.0 | 185.0 | 745.6 |
| 130 | 4.5 | 0.9 | 32.9 | 38.0 | 248.0 | 993.8 |
| 150 | 4.1 | 0.8 | 43.3 | 54.0 | 385.0 | 1664.3 |
| 200 | 3.5 | 0.6 | 69.7 | 114.0 | 722.0 | 2131.2 |
| 400 | 2.3 | 0.9 | 131.6 | 195.0 | 217.0 | 560.1 |
| 600 | 1.8 | 1.2 | 131.0 | 160.0 | 78.5 | 192.4 |

These data are also presented graphically in **Figure 5.1** showing a two-dimensional view of the plume development from the point of release for the emergency scenario. The maximum lateral cross-wind spread of the plume has been projected on to the x direction. This figure allows the regions of space where the maximum average in-plume vertical velocity exceeds 4.3 m/s to be determined.

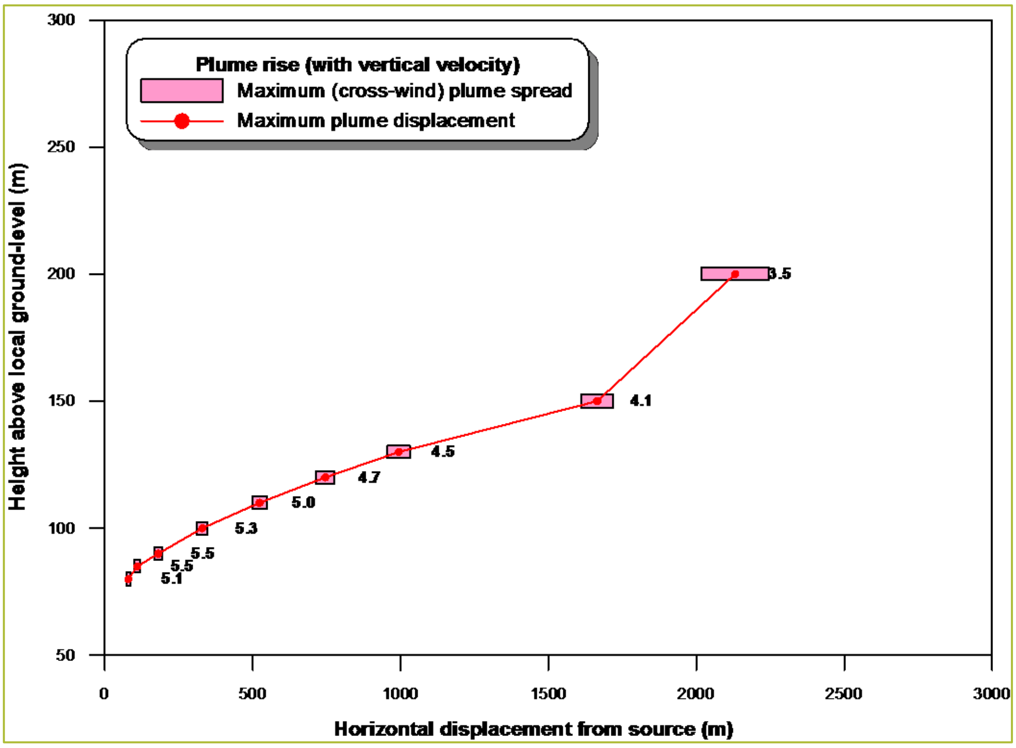


**Figure 5.2: Plume development – Emergency Scenario**

CASA require information on the heights above the ground at which the average vertical velocity of the plume exceeds the critical vertical velocity (4.3 m/s) for various percentages of time. However, as discussed in **Section 5.1.1**, plume rise drops off rapidly and TAPM output cannot be interpolated for predictions that occur within 1 second of the plume being released. **Table 5.4** shows the heights above ground where the average vertical velocity exceeds 4.3 m/s for selected percentiles where data is able to be interpolated. These results suggest that the probability of the maximum average in-plume vertical velocity exceeding 4.3 m/s at say, 98 m (115 m AHD), is approximately 0.2%.

However, it is also important to note that the way the emergency scenario is modelled, has to assume this scenarios is continuous. In reality, the frequency of occurrence of emergency events would be limited to approximately 1 per year with an expected duration of 15 minutes. On this basis, the emergency event would occur for just 0.003 % of the year and the percentage frequency of exceedance in **Table 5.4** only applies to 0.003 % of the time.

**Table 5.4: Percentage of time that maximum vertical velocity exceeds 4.3 m/s**

| Frequency of exceedance of 4.3 m/s (%) | Height above ground level (m) | Height above sea level (m AHD) |
|---|---|---|
| 100 | 70 | 87 |
| 1 | 80 | 97 |
| 0.5 | 87 | 104 |
| 0.3 | 93 | 110 |
| 0.2 | 98 | 115 |
| 0.1 | 106 | 123 |
| 0.05 | 113 | 130 |

## 5.2 Vaporisation package stack

The gradual plume rise data has been analysed for the two vaporisation stacks at the gas plant. Review of this data indicate that, similar to the sour gas flare scenario (see **Section 5.1.1**), the point in time that the in-plume vertical velocity falls below the critical value of 4.3 m/s is within the first second of the TAPM predictions and therefore an approximate height cannot be interpolated.

In summary, at the release height of 10 m (27 m AHD) the critical vertical velocity is exceeded 100% of the time and at 15 m (32 m AHD) it is exceeded 0% of the time.

## 5.3 Wind Speed

Hourly wind speed data at selected heights were extracted from the TAPM generated profile data. **Table 5.5** summarises the wind speeds for a number of heights above ground level for the start up / shut down scenario. **Table 5.6** summarises the wind speeds for a number of heights above ground level for the emergency scenario.

**Table 5.5: TAPM simulated wind statistics for start-up / shut down**

| Height above local ground-level (m) | Average wind speed at this level (m/s) | Maximum wind speed at this level (m/s) |
|---|---|---|
| Lowest (43) | 4.1 | 15.4 |
| 52 | 4.1 | 15.5 |
| 60 | 4.3 | 16.0 |
| 70 | 4.5 | 16.6 |
| 80 | 4.8 | 17.2 |
| 90 | 5.0 | 17.8 |
| 100 | 5.3 | 18.4 |
| 120 | 5.6 | 19.0 |
| 150 | 6.2 | 19.9 |
| 200 | 6.8 | 20.8 |
| 400 | 7.9 | 22.9 |
| 600 | 7.9 | 23.9 |

**Table 5.6: TAPM simulated wind statistics for Emergency Scenario**

| Height above local ground-level (m) | Average wind speed at this level (m/s) | Maximum wind speed at this level (m/s) |
|---|---|---|
| Lowest (76) | 4.7 | 17.0 |
| 80 | 4.8 | 17.2 |
| 85 | 4.9 | 17.5 |
| 90 | 5.0 | 17.8 |
| 100 | 5.3 | 18.4 |
| 110 | 5.4 | 18.7 |
| 120 | 5.6 | 19.0 |
| 130 | 5.8 | 19.3 |
| 150 | 6.2 | 19.9 |
| 200 | 6.8 | 20.8 |
| 400 | 7.9 | 22.9 |
| 600 | 7.9 | 23.9 |

**Appendix A** provides histograms of wind speed at each height, as required by CASA. The graphs show the frequency of occurrence of all wind speeds as well as low wind speeds (winds less than or equal to 0.5 m/s).

# 6 CONCLUSIONS

This report presents the results plume rise modelling for the proposed Newcastle Gas Storage Facility. The gradual plume rise under four operational conditions was investigated.

The plume rise modelling was conducted using TAPM in accordance with the requirements of CASA and results were presented such that the regions of space where the vertical plume velocity exceeded 4.3 m/s could be determined.

When the flare is operating under normal conditions the exit velocity of the plume is less than the critical vertical velocity and was not considered further. This was also the case for the plume release from the hot oil heaters.

The plume rise predictions for the sour gas flare scenario and the two vaporisation package stacks were shown to fall below the critical velocity within 1 second after being released. The height that this occurs cannot be precisely resolved, however it can be stated that this is less than 40 m (57 m AHD) and 15 m (32 m AHD) respectively.

Plume rise results for the flare operating under start-up / shutdown and emergency conditions indicate that the critical vertical velocity is not exceeded at 115 m (132 m AHD) and 140 m (157 m AHD), respectively.

# 7 REFERENCES


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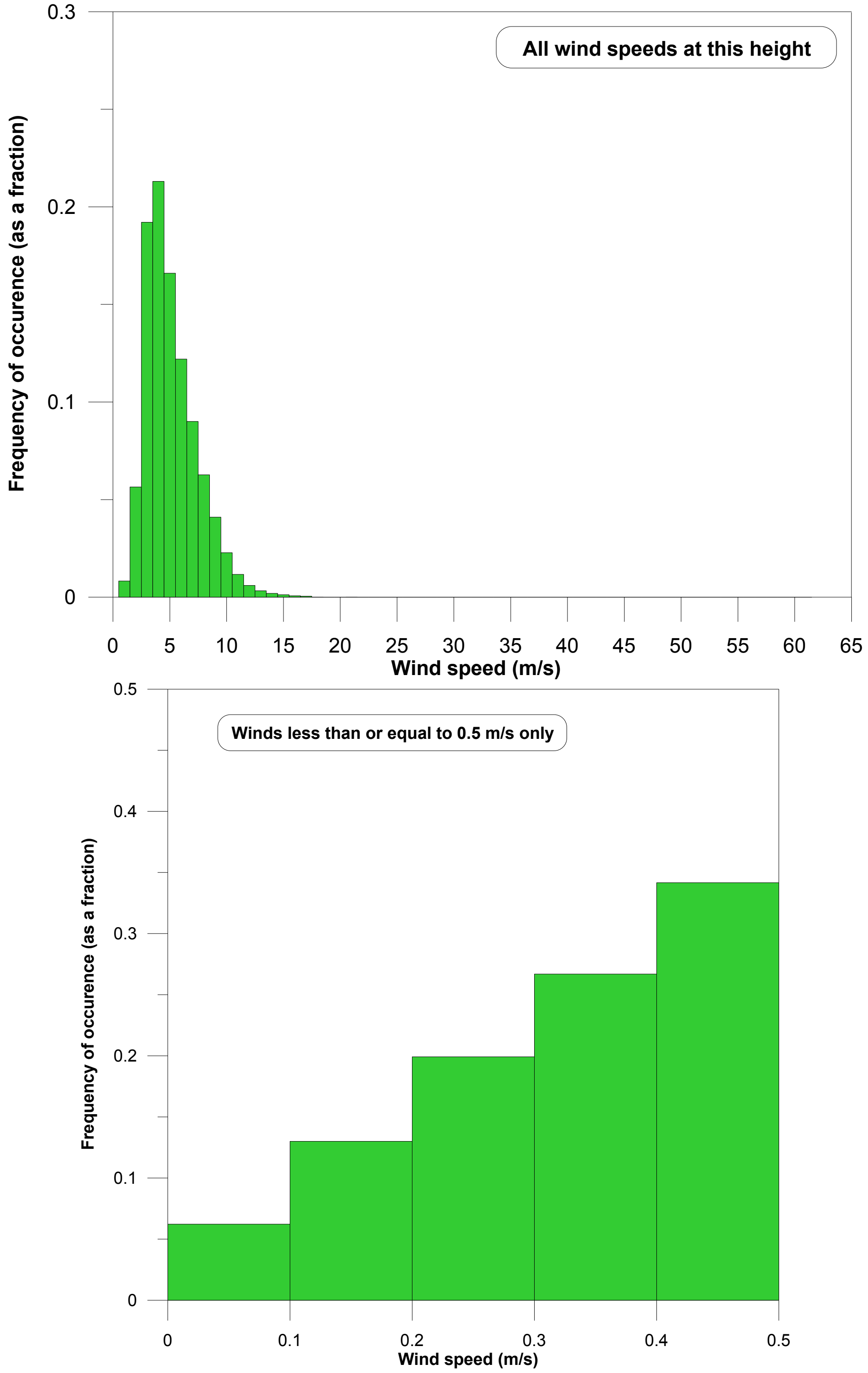
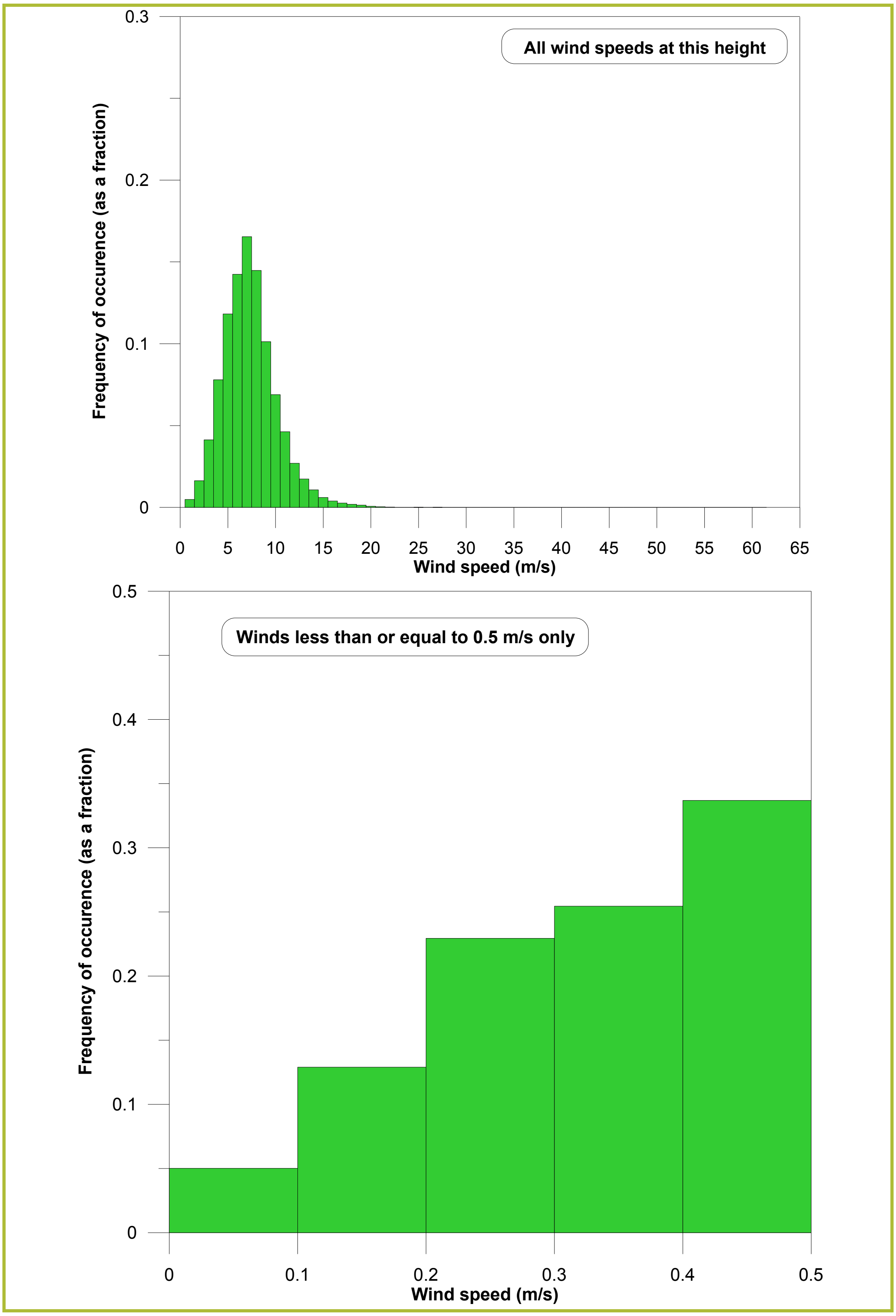
## APPENDIX A

## Plume Rise and Wind Speed - Graphical Analysis

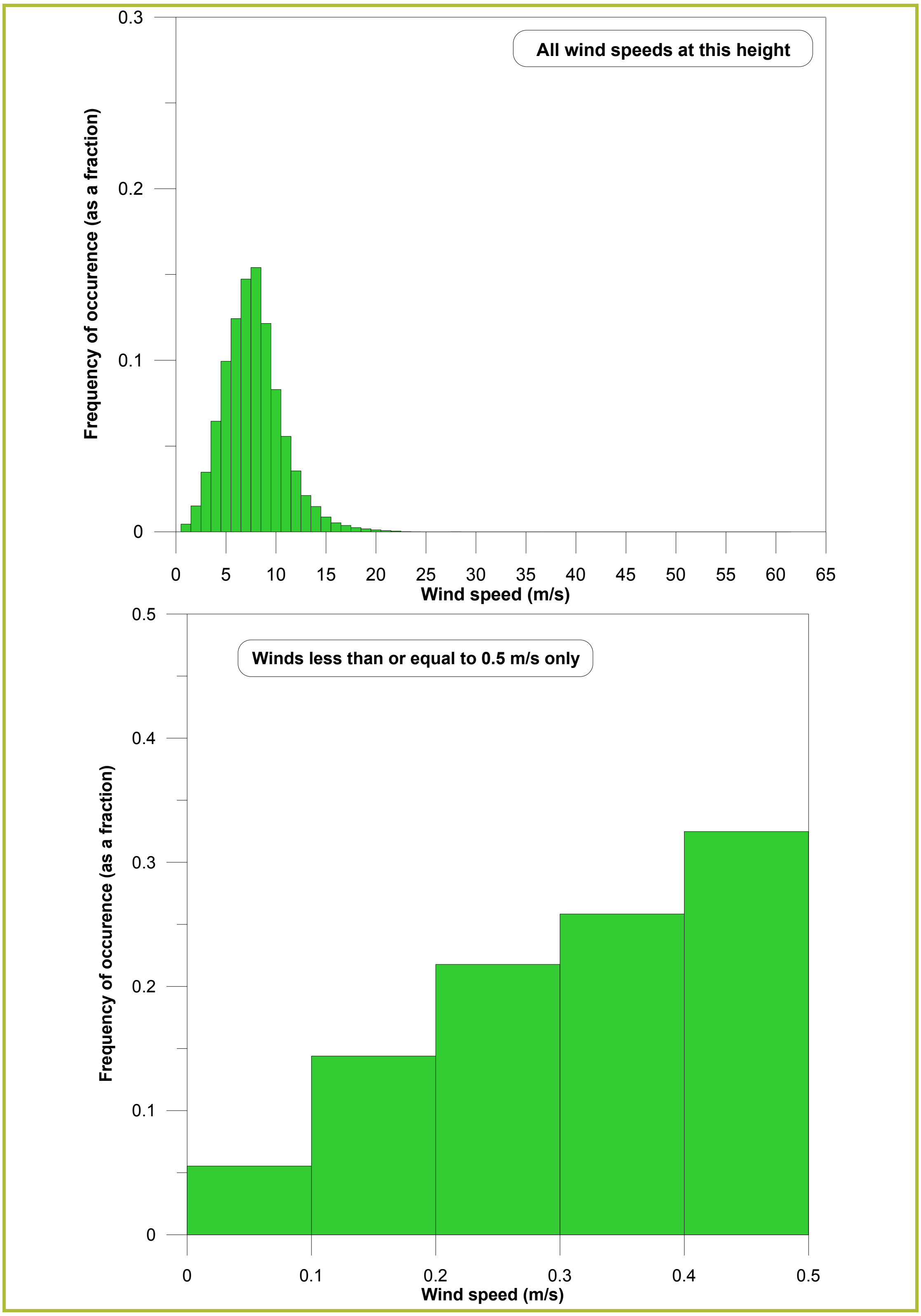
**Histogram of TAPM simulated wind speed at 32 m above ground**



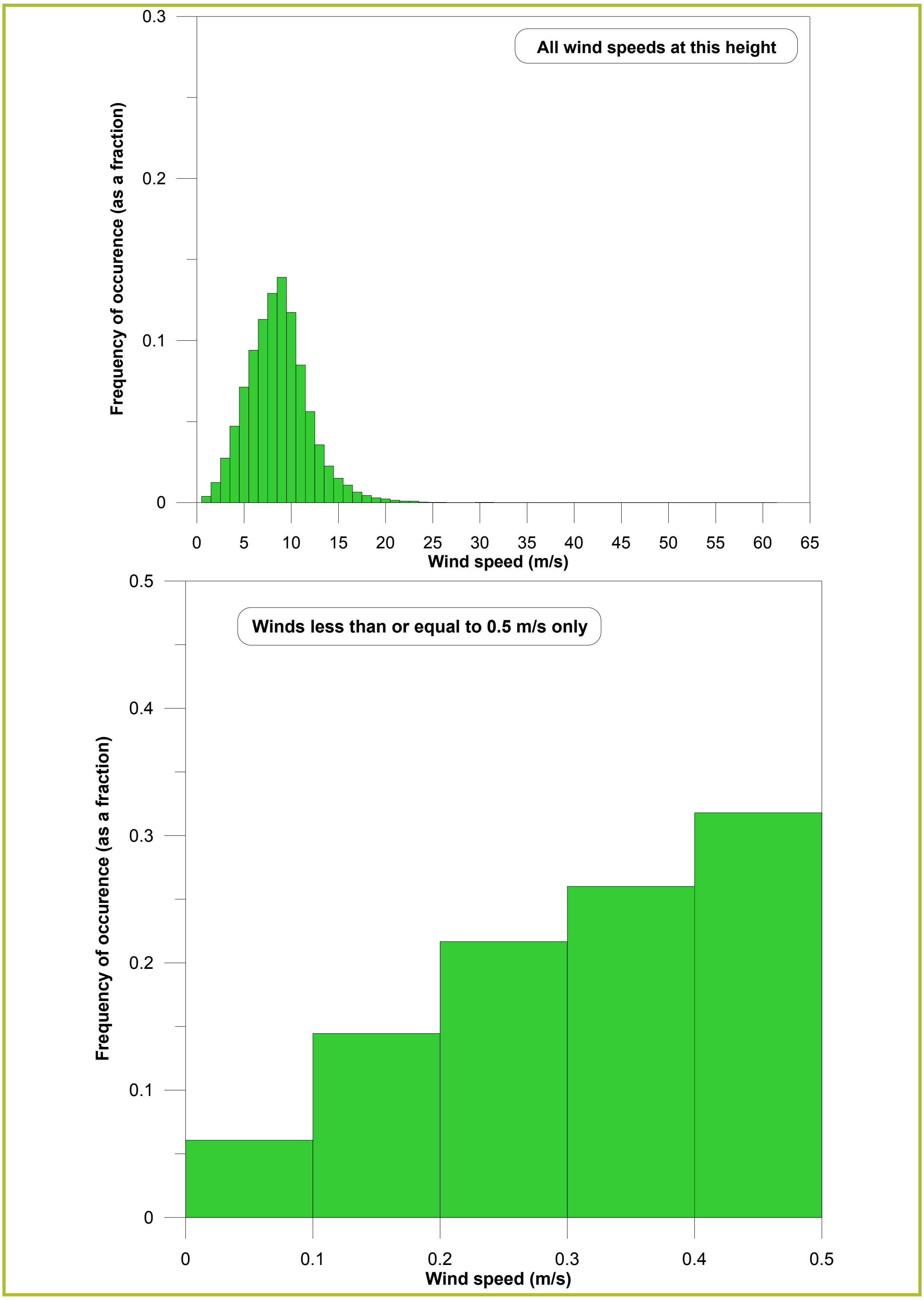
**Histogram of TAPM simulated wind speed at 35 m above ground**



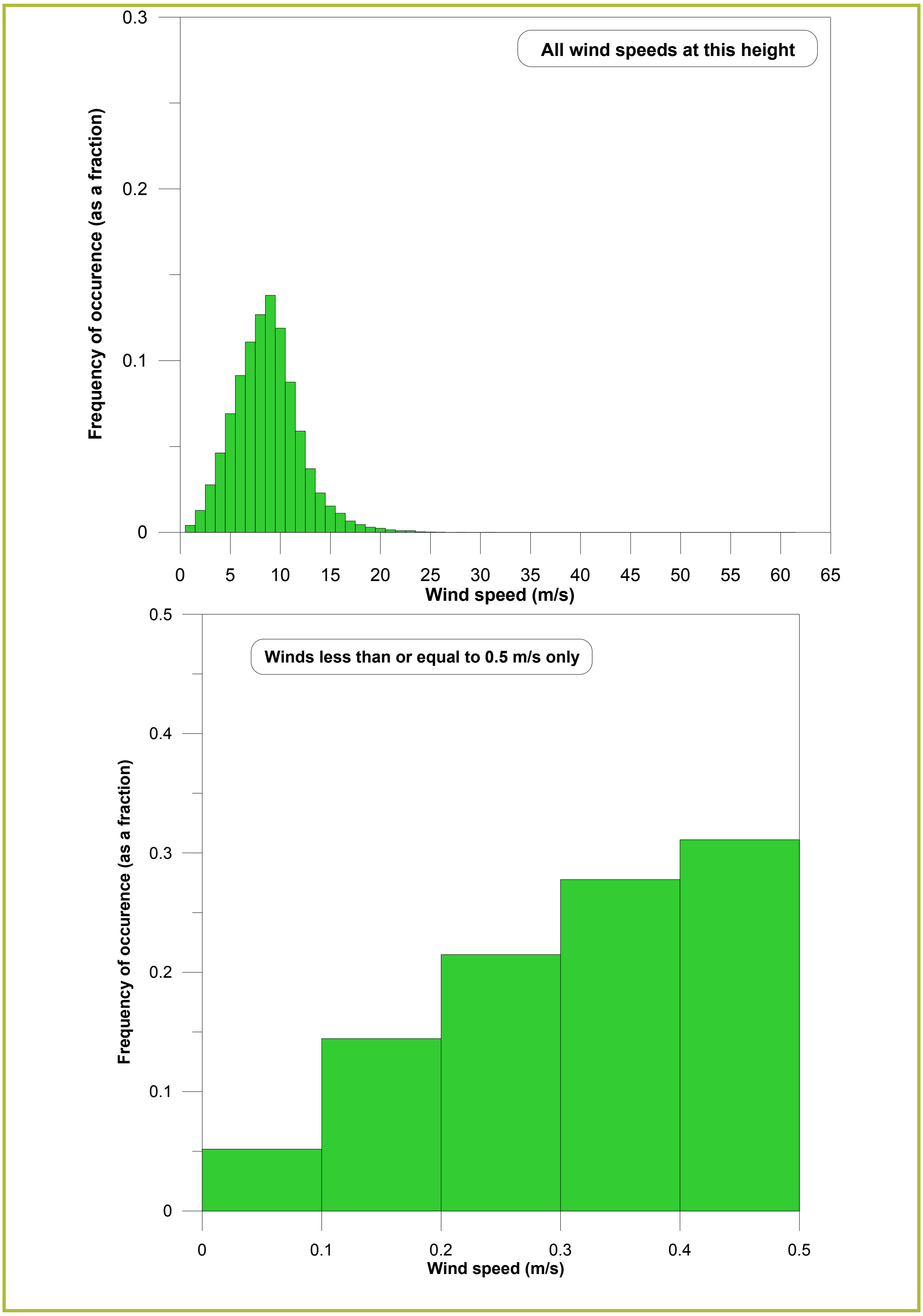
## Histogram of TAPM simulated wind speed at 40 m above ground



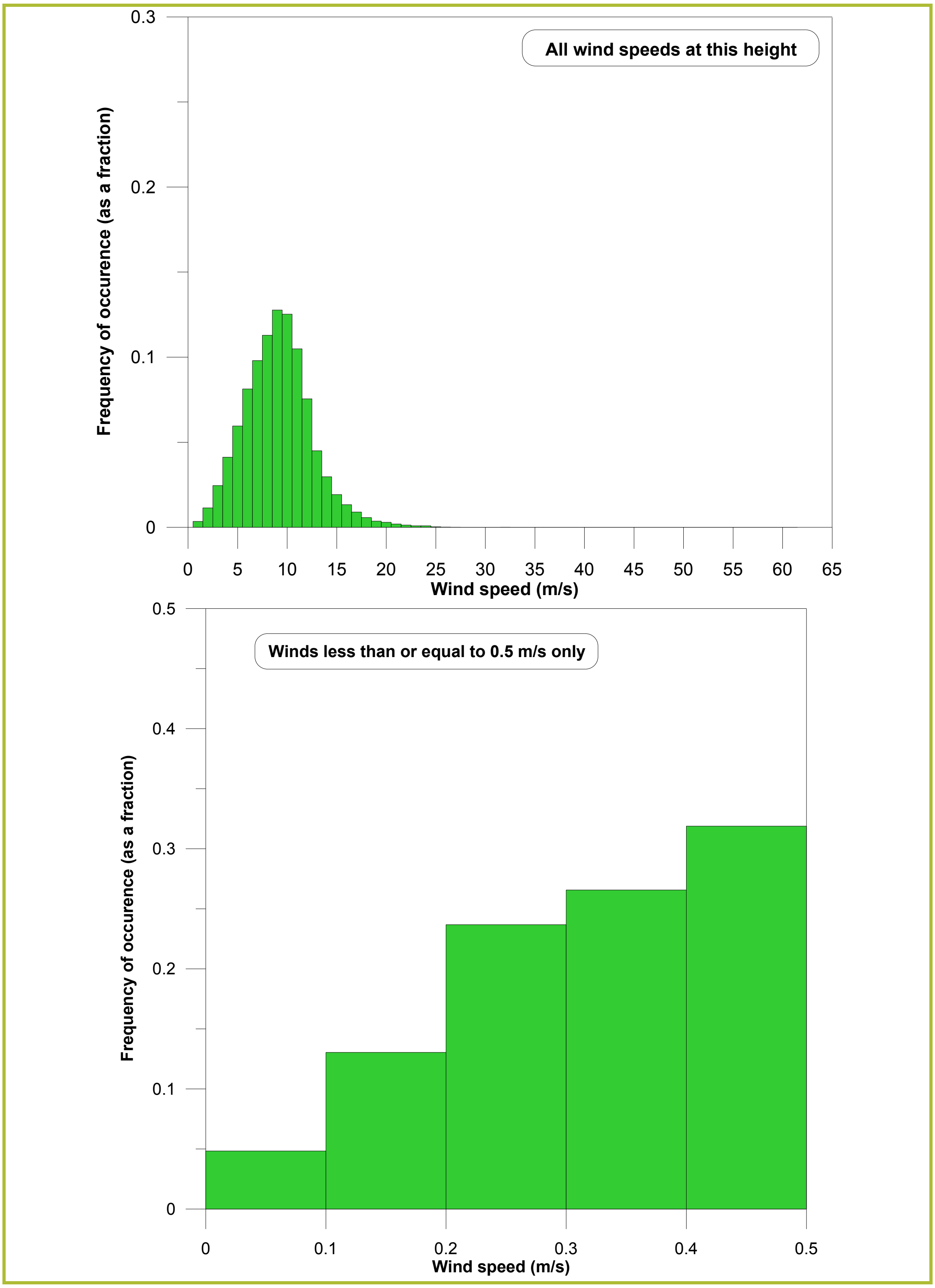
**Histogram of TAPM simulated wind speed at 50 m above ground**



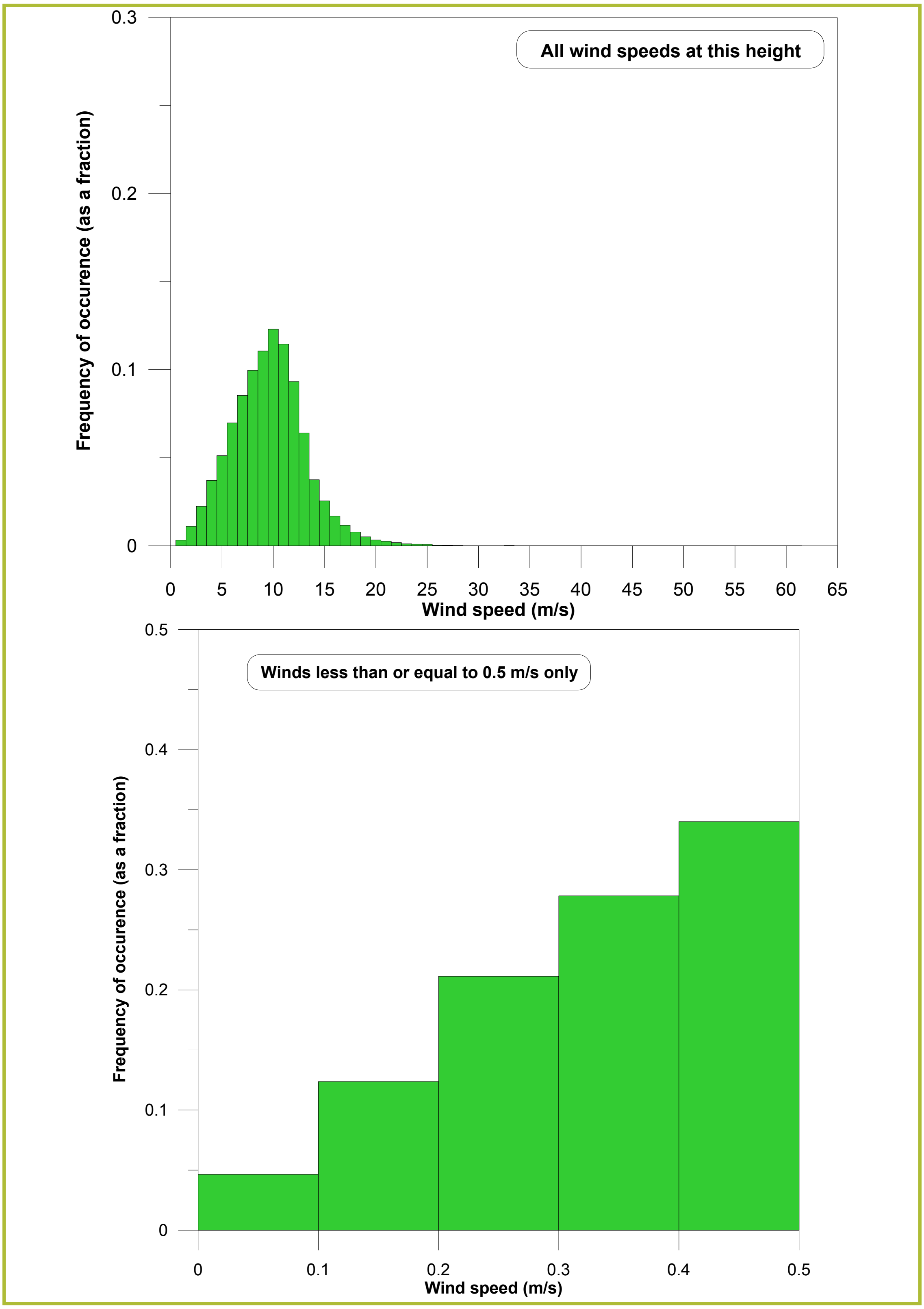
**Histogram of TAPM simulated wind speed at 52 m above ground**



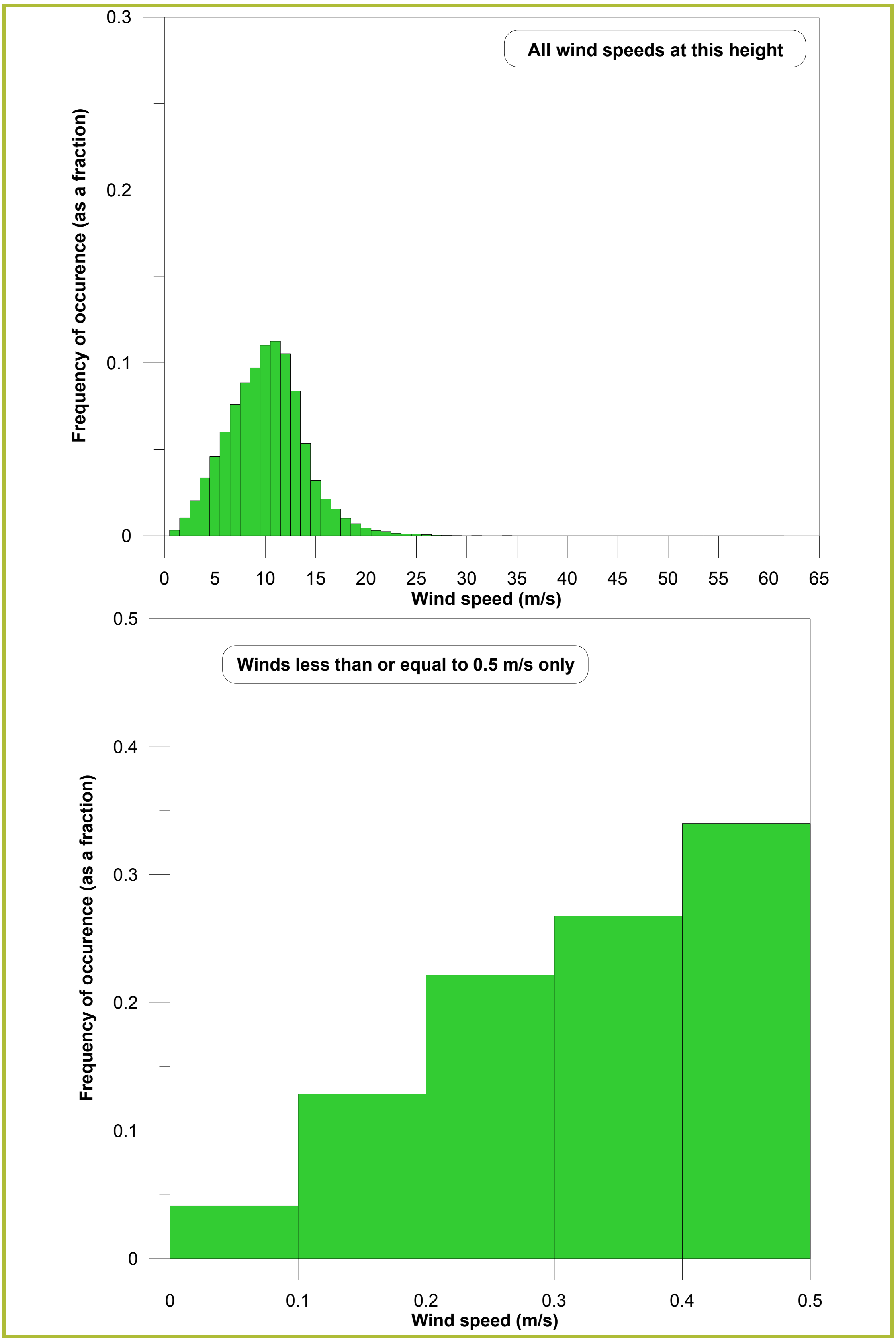
**Histogram of TAPM simulated wind speed at 60 m above ground**



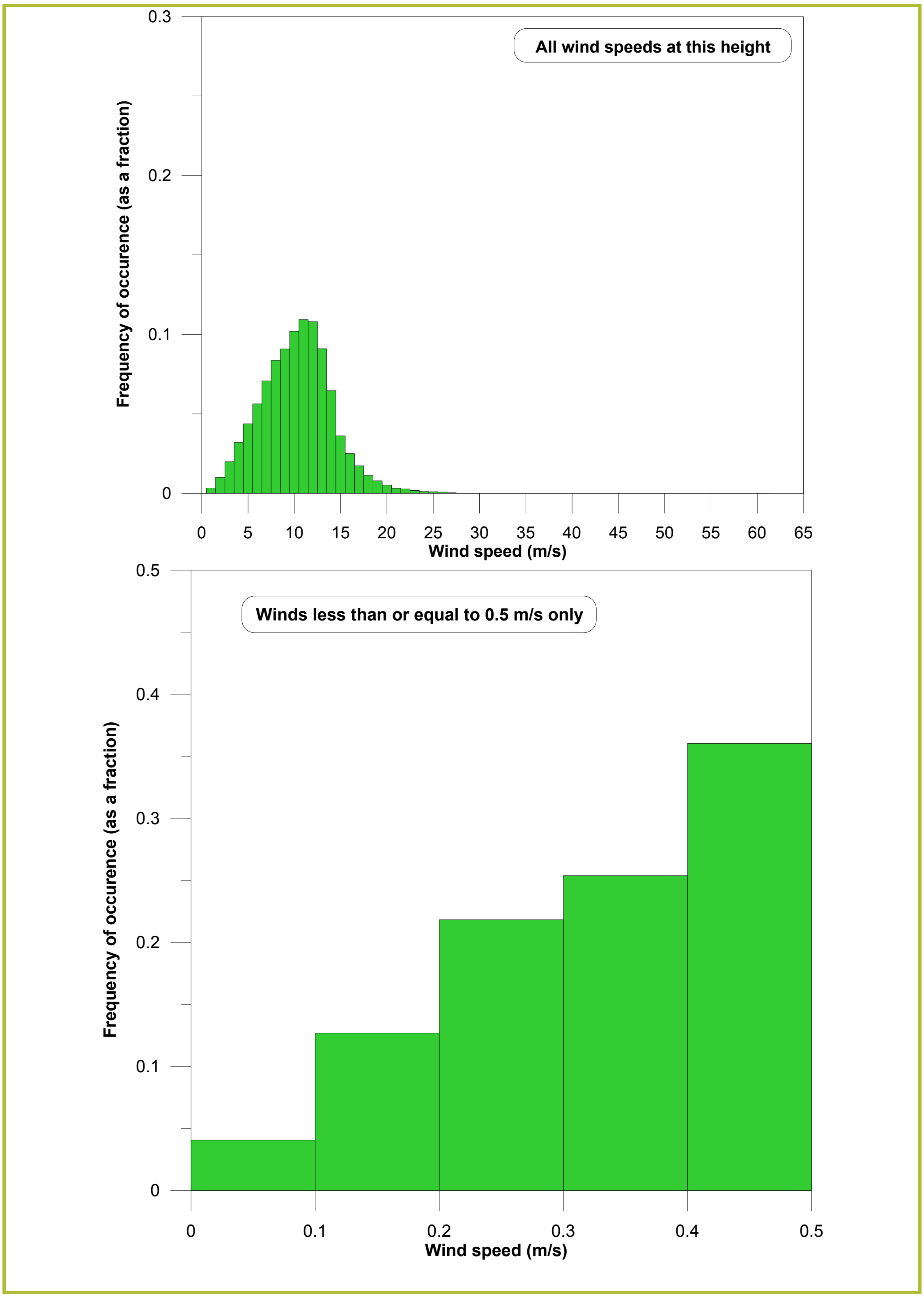
**Histogram of TAPM simulated wind speed at 76 m above ground**



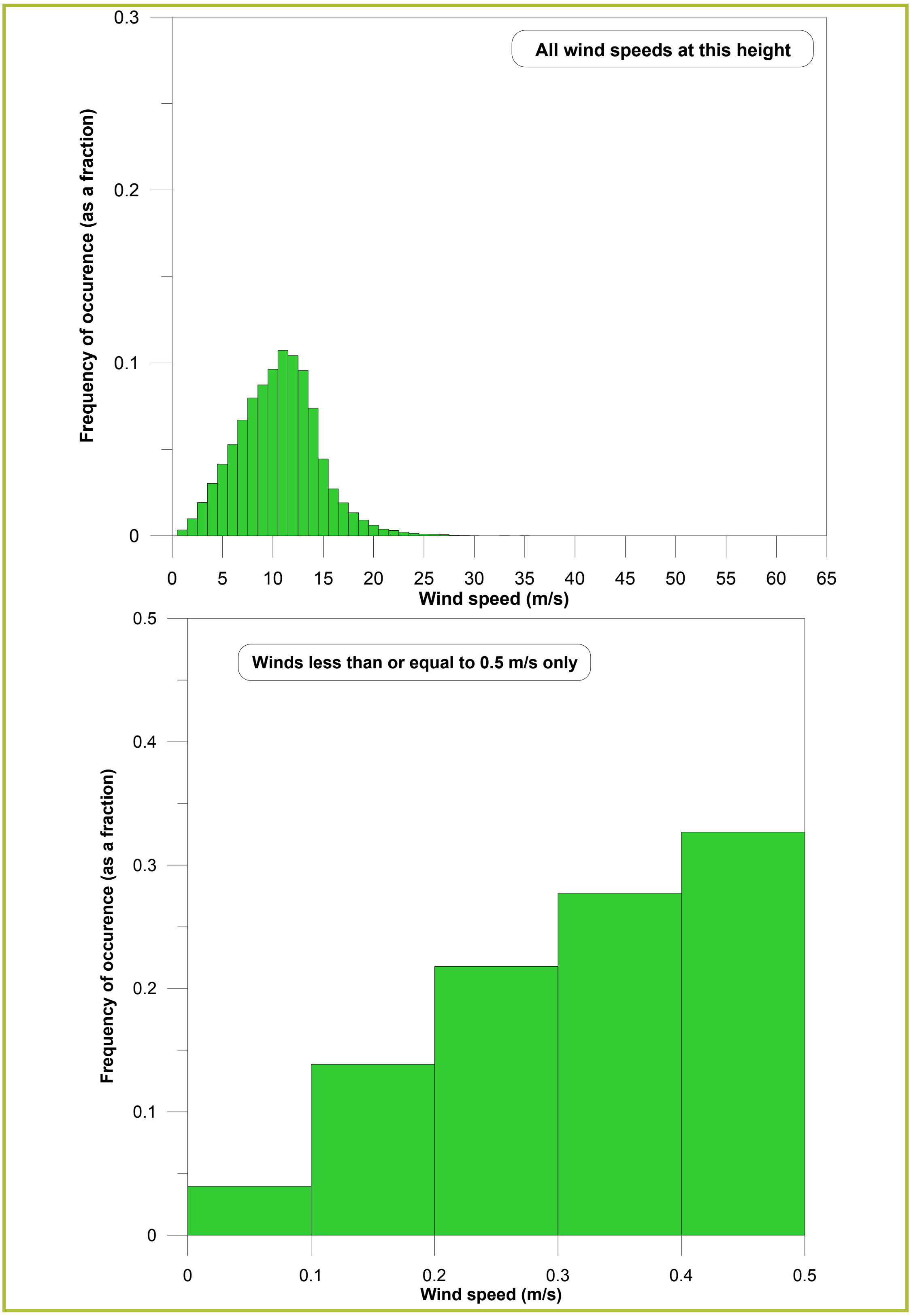
**Histogram of TAPM simulated wind speed at 80 m above ground**



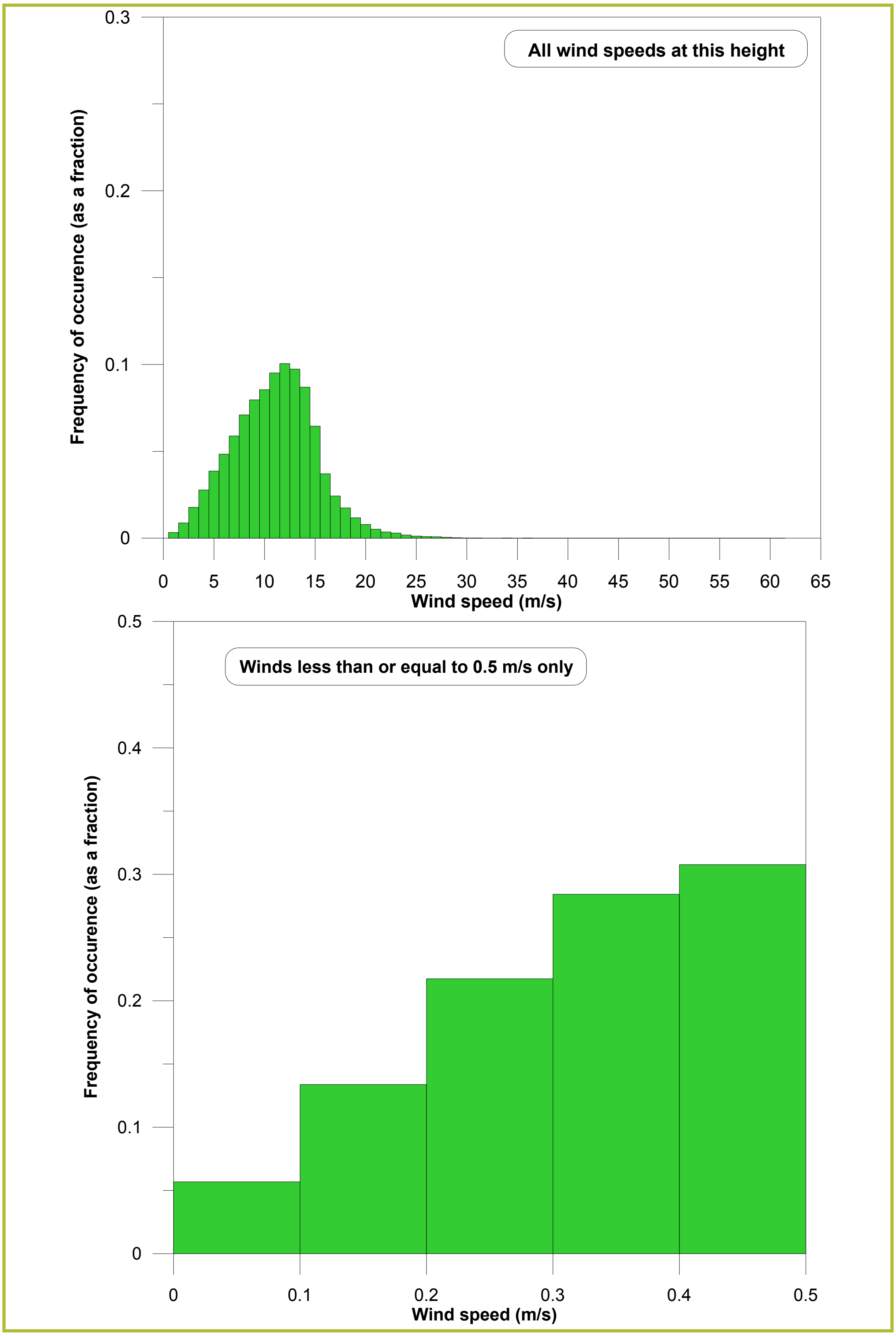
**Histogram of TAPM simulated wind speed at 85 m above ground**



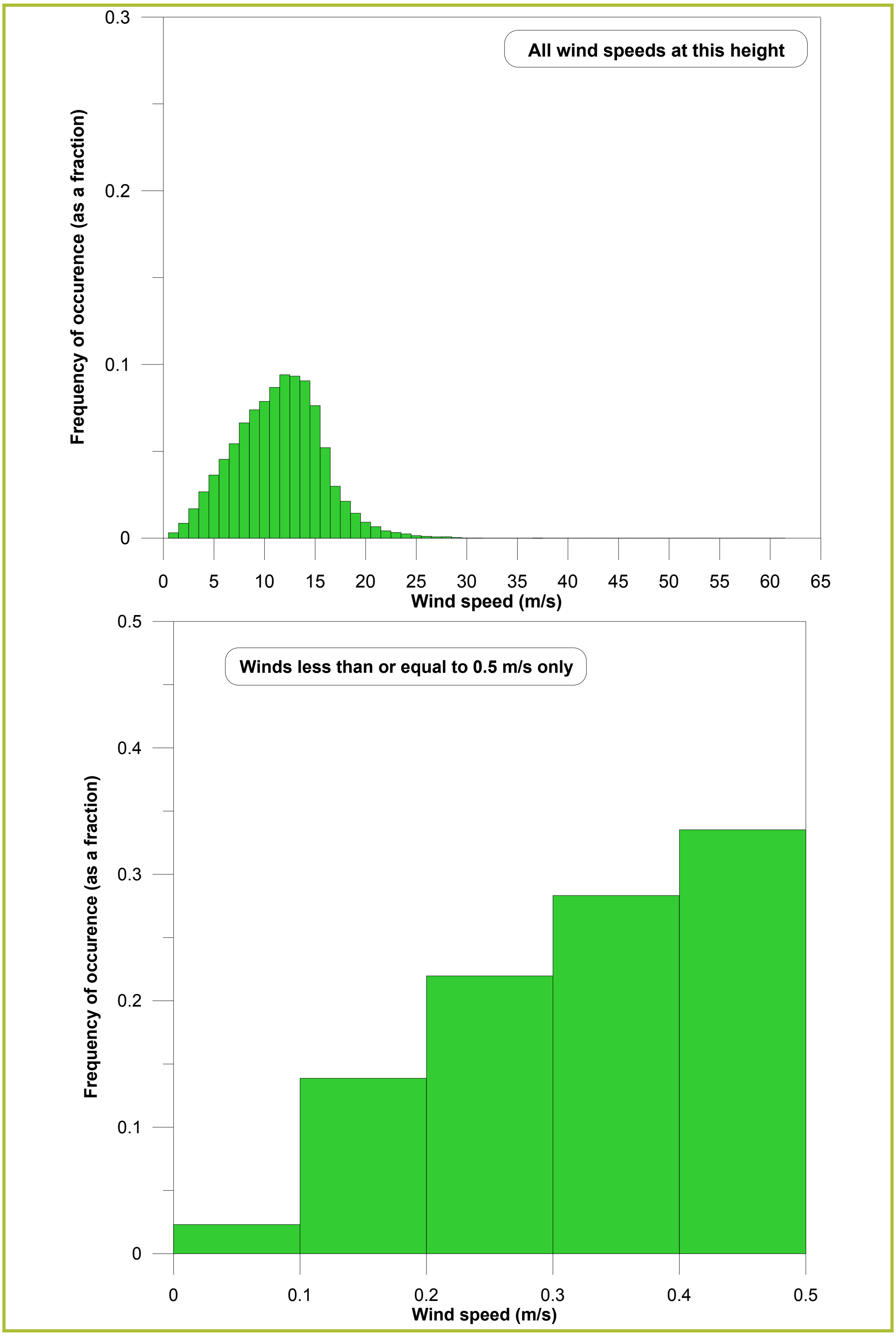
**Histogram of TAPM simulated wind speed at 90 m above ground**



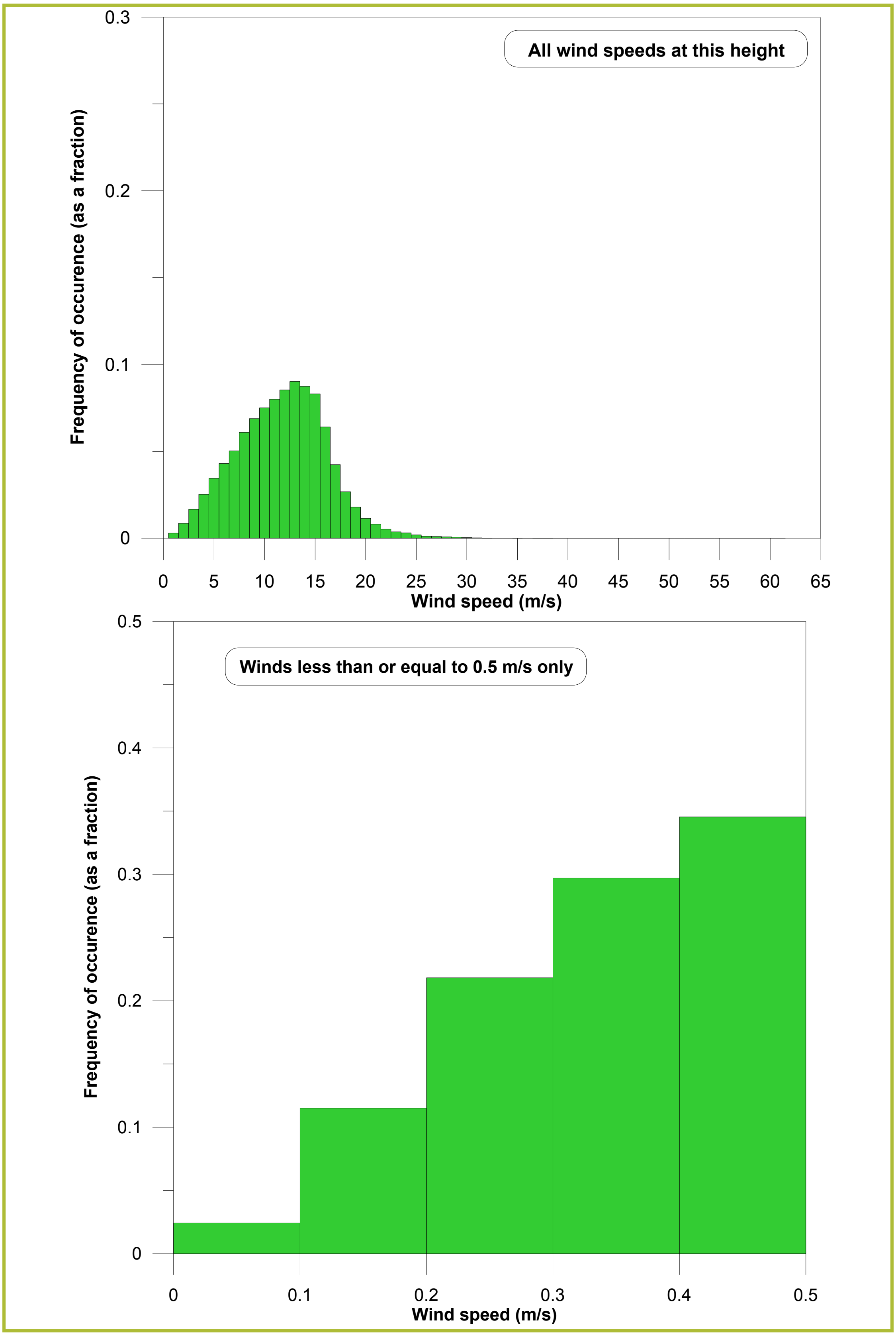
**Histogram of TAPM simulated wind speed at 100 m above ground**



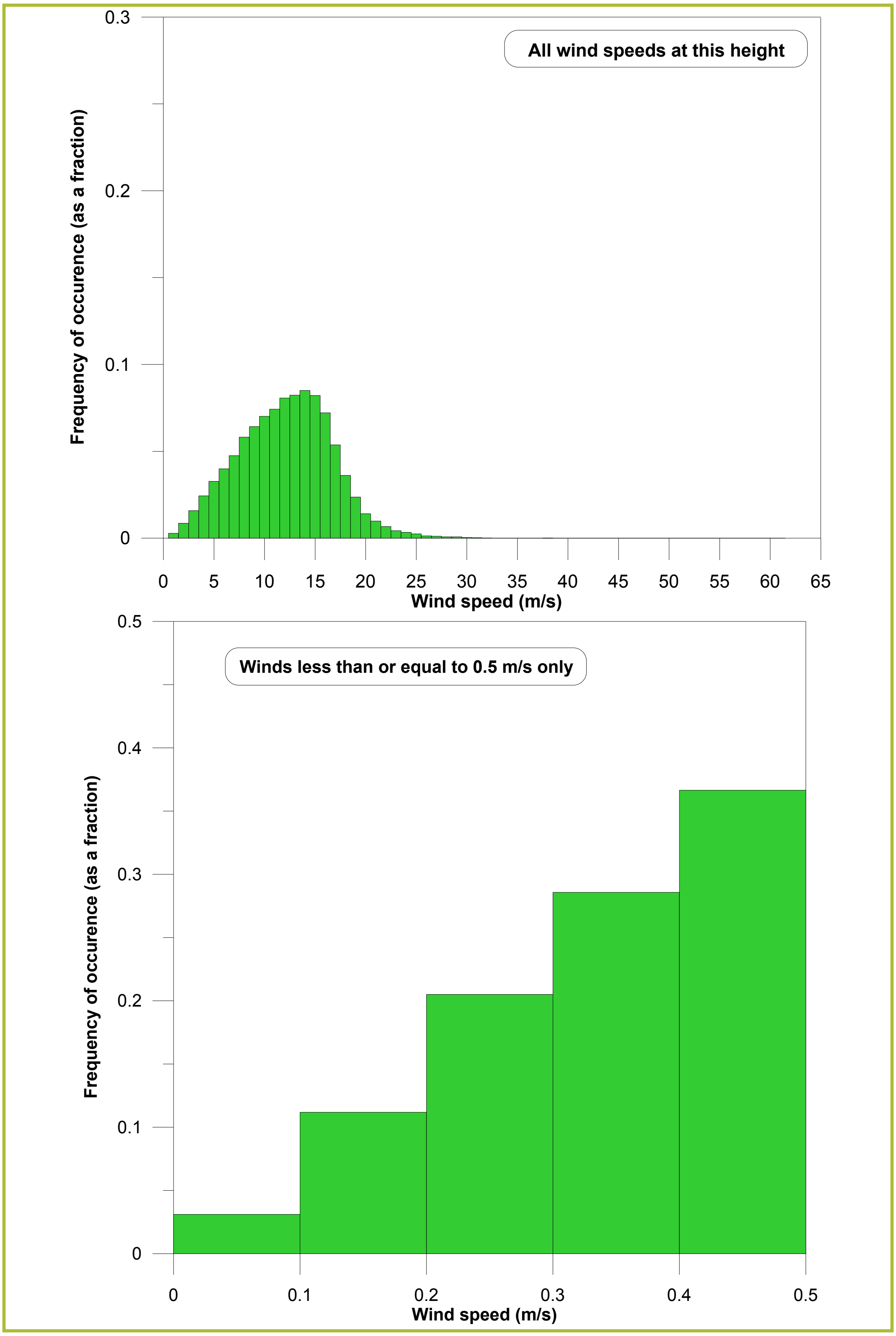
**Histogram of TAPM simulated wind speed at 110 m above ground**



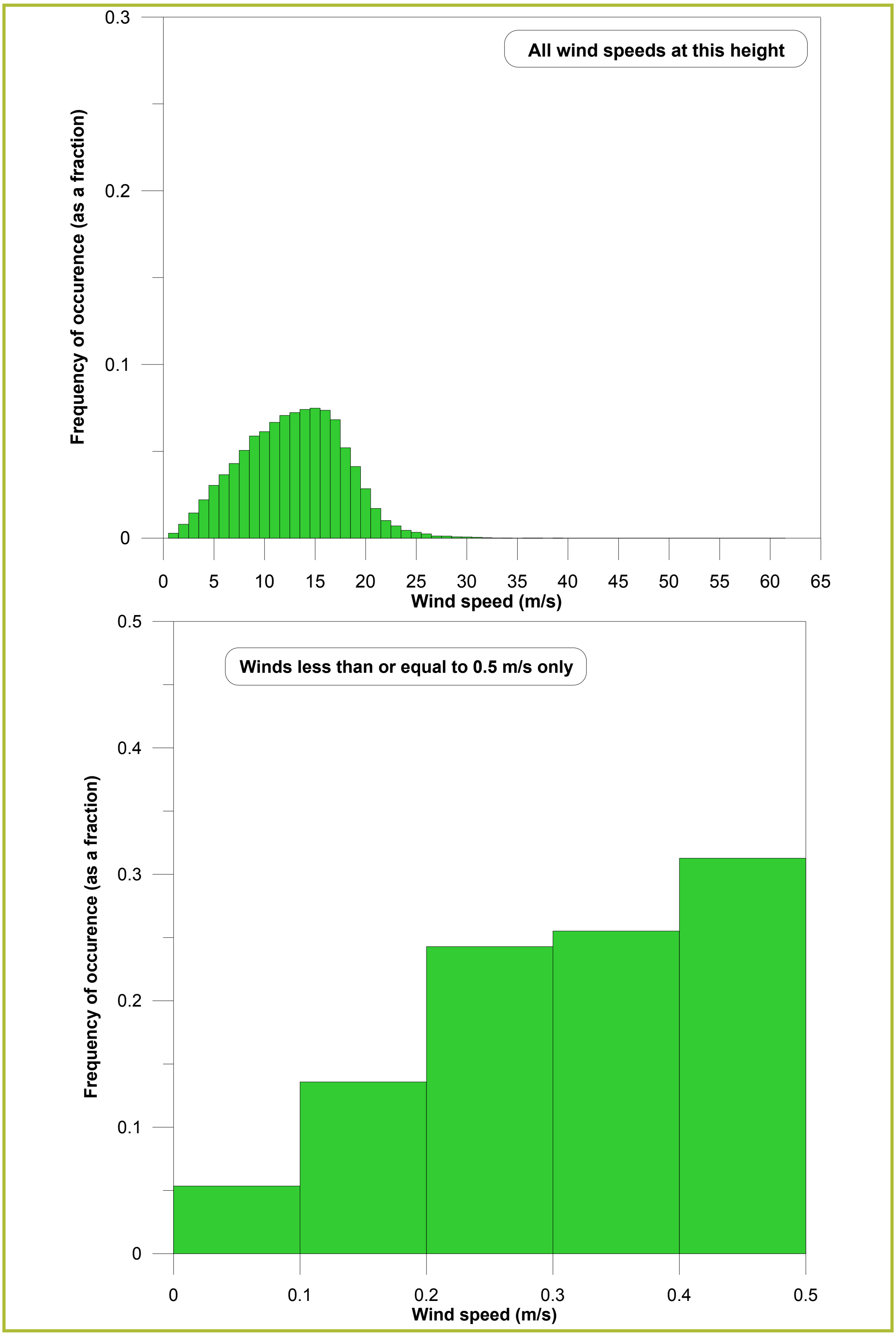
**Histogram of TAPM simulated wind speed at 120 m above ground**



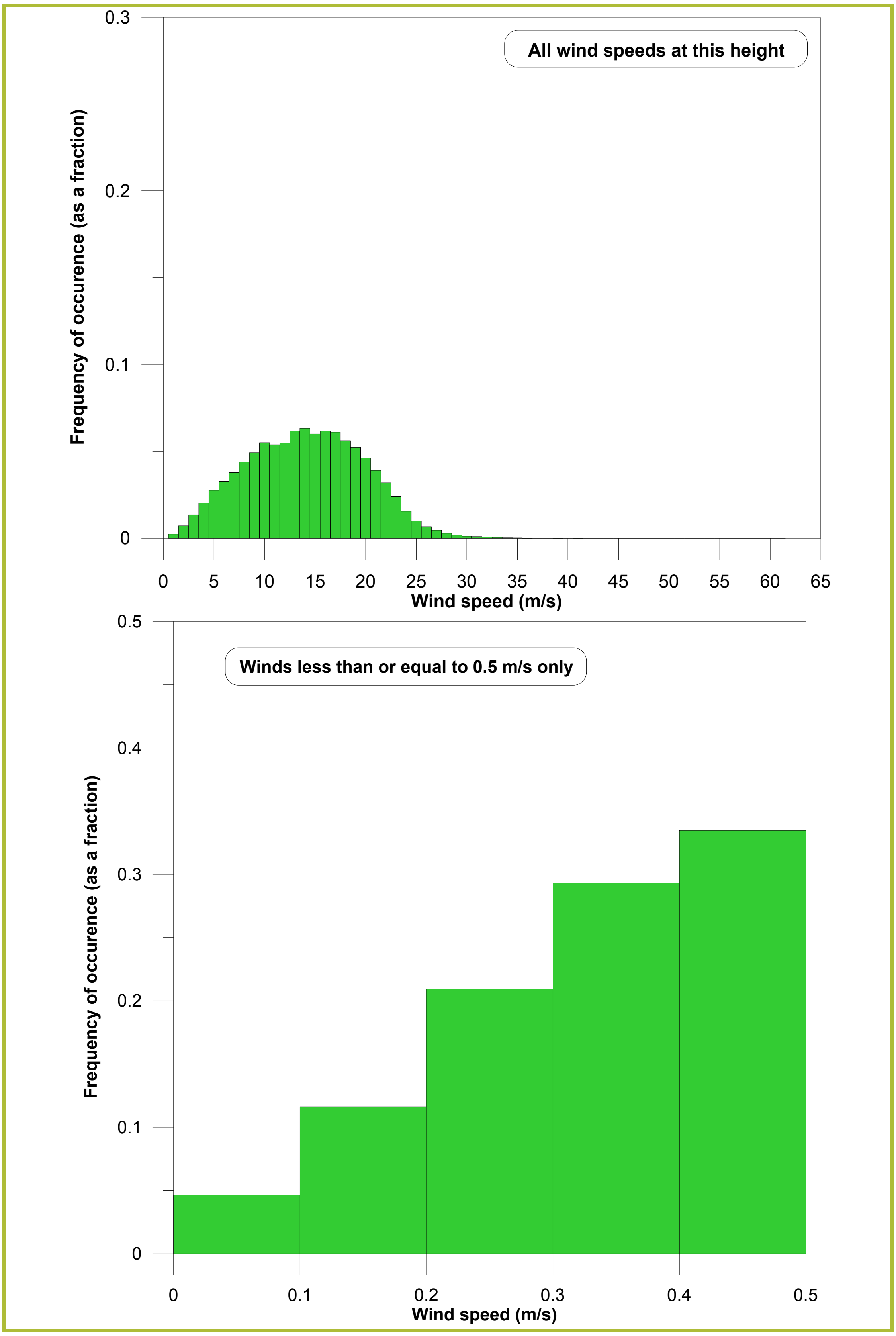
**Histogram of TAPM simulated wind speed at 130 m above ground**



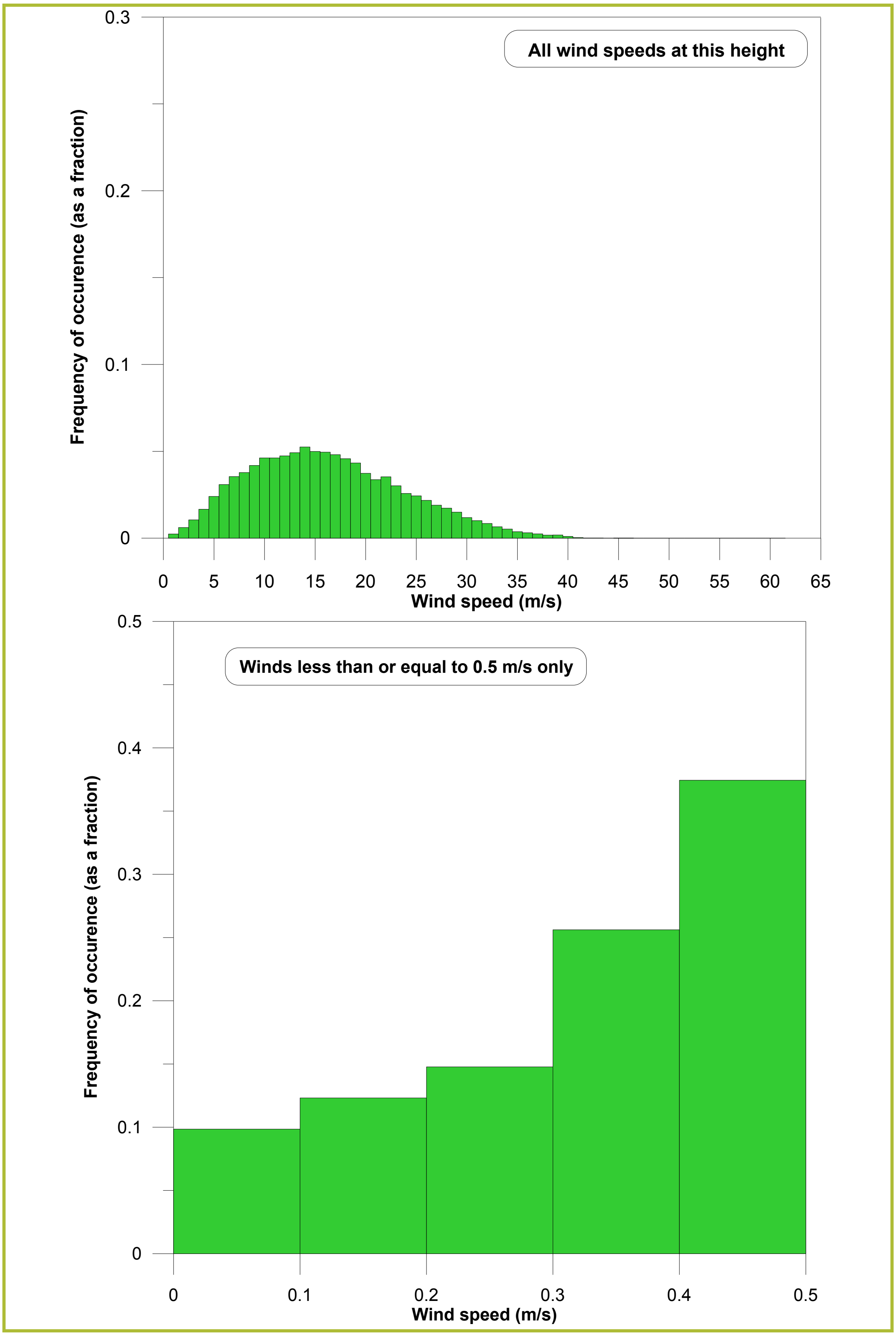
## Histogram of TAPM simulated wind speed at 150 m above ground



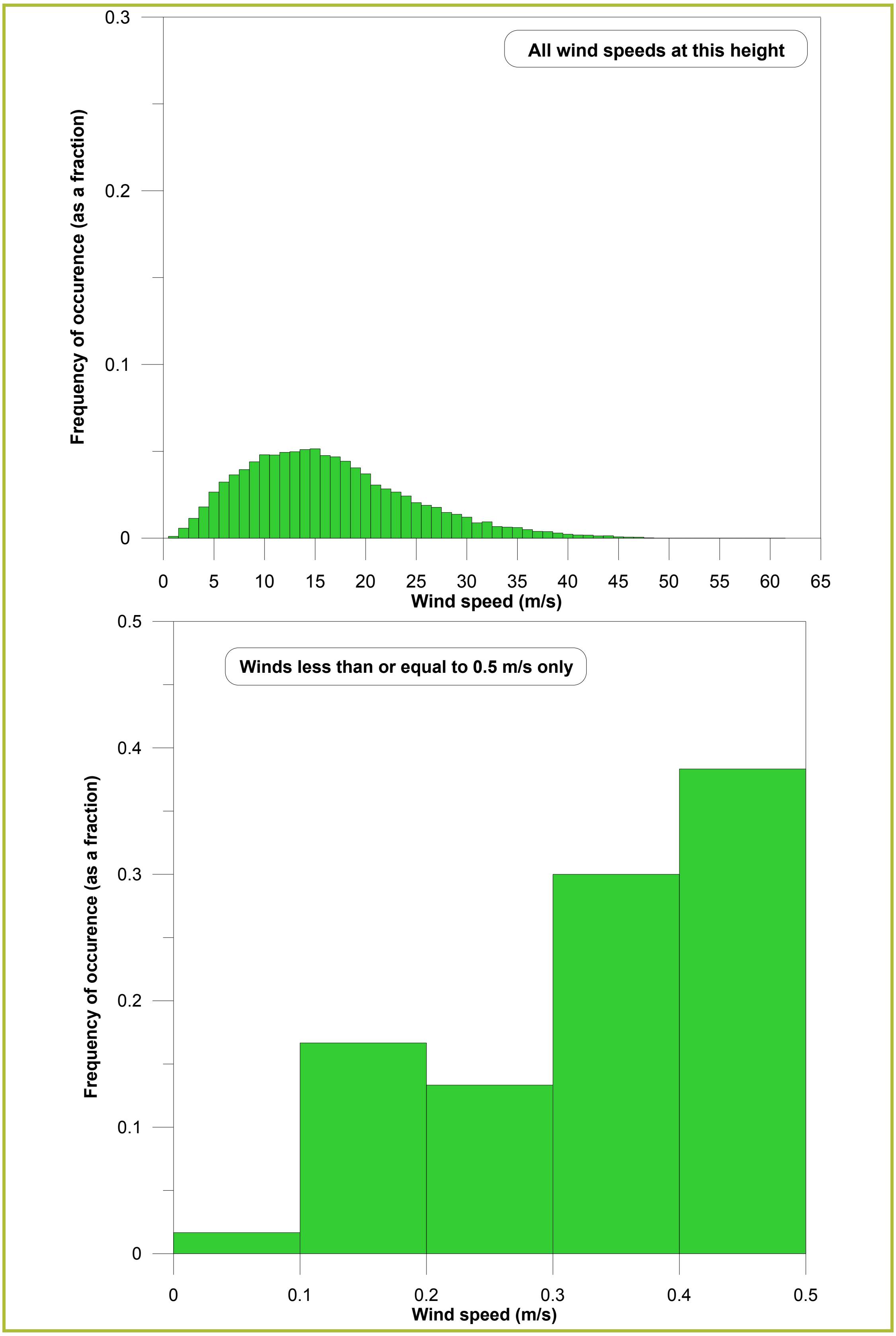
**Histogram of TAPM simulated wind speed at 200 m above ground**



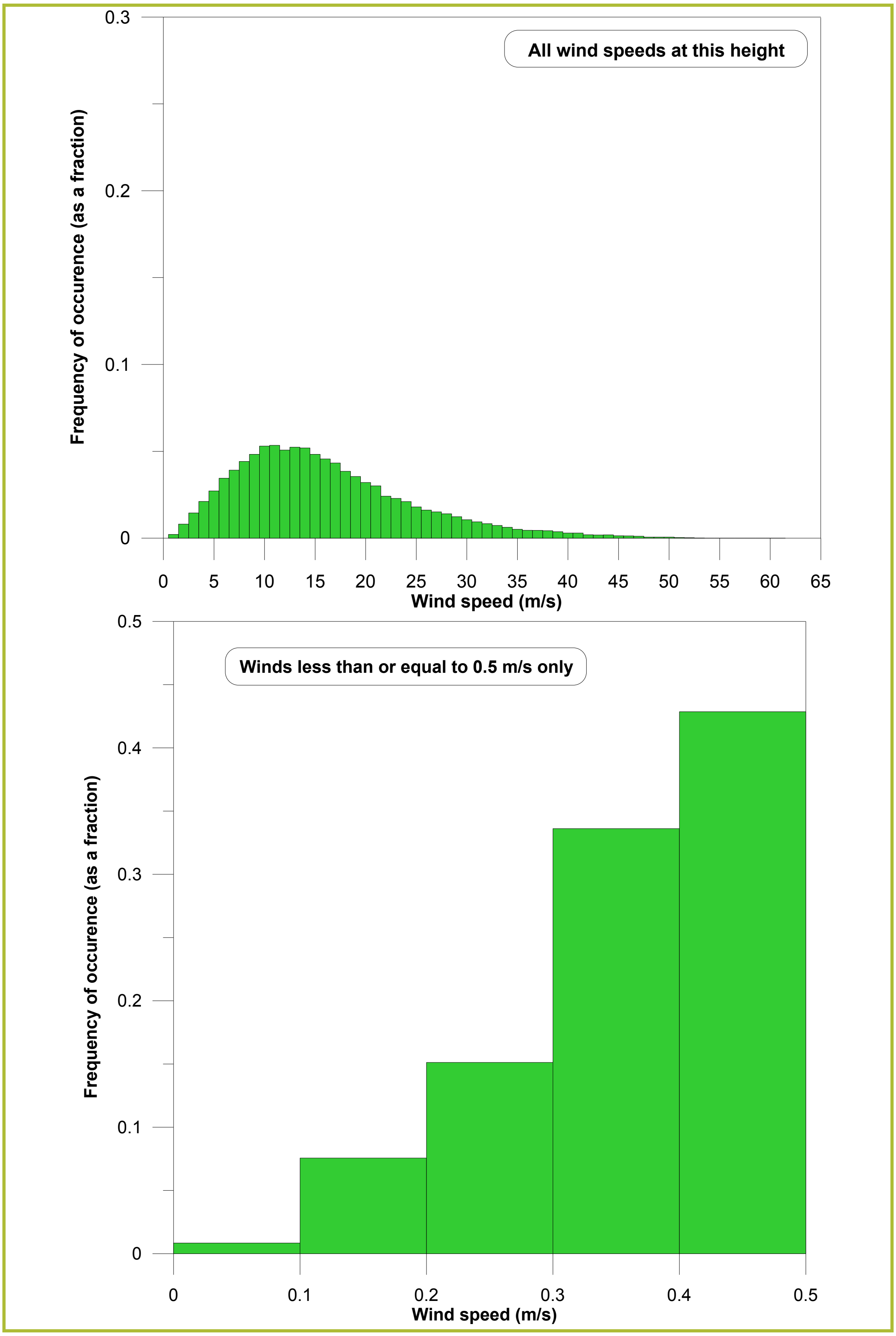
**Histogram of TAPM simulated wind speed at 400 m above ground**



**Histogram of TAPM simulated wind speed at 600 m above ground**



**Histogram of TAPM simulated wind speed at 800 m above ground**



**Histogram of TAPM simulated wind speed at 1000 m above ground**