



INTEGRATED
ENVIRONMENTAL
SOLUTIONS

14949

Holy Cross College SHD

Pedestrian Comfort CFD Analysis

Report P4-03

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Contents

1	Executive Summary	5
1.1	Sitting and Standing Comfort.....	6
1.1.1	Ground Level.....	6
1.1.2	Balconies.....	7
1.1.3	Roof Top Communal Spaces.....	7
1.2	Walking Comfort.....	7
1.3	Safety Criteria.....	7
2	Development Description	8
3	Weather Data	9
4	Wind Boundary Layer	10
5	Methodology for Pedestrian Comfort Calculation	12
5.1	Lawson Pedestrian Comfort/Safety Criteria.....	12
6	CFD Model	13
6.1	Model Geometry.....	13
6.2	Comfort Activities.....	28
7	Results	29
7.1	Comfort Criteria: All Seasons.....	29
7.1.1	Sitting Comfort Criteria.....	29
7.1.2	Standing Comfort Criteria.....	37
7.1.3	Leisure Walking Comfort Criteria.....	45
7.1.4	Business Walking Comfort Criteria.....	53
7.2	Safety Criteria: All Seasons.....	61
7.2.1	Normal Pedestrian Safety Criteria.....	61
7.2.2	Sensitive Pedestrian Safety Criteria.....	69

Figures

Figure 1: Wind speed variation as per DublinIWEC.epw	9
Figure 2: Wind direction variation as per DublinIWEC.epw	9
Figure 3: Wind rose as per DublinIWEC.epw	9
Figure 4: Typical velocity profile of an atmospheric boundary layer	10
Figure 5: Wind boundary profile for the CFD simulations using annual average wind speed	11
Figure 6: Plan view of the site	13
Figure 7: View of the site from the south	13
Figure 8: View of the site from the west	14
Figure 9: View of the site from the north	14
Figure 10: View of the site from the east	15
Figure 11: Closer view of site from the south	15
Figure 12: Closer view of site from the west	16
Figure 13: Closer view of site from the north	16
Figure 14: Closer view of site from the east	17
Figure 15: Closer view of site the South	17
Figure 16: Closer view of site from the west	18
Figure 17: Closer view of site from the north	18
Figure 18: Closer view of site from the east	19
Figure 19: Closer view of site from the South	19
Figure 20: Closer view of site from the West	20
Figure 21: Closer view of site from the North	20
Figure 22: Closer view site from east	21
Figure 23: Closer view site from the south	21
Figure 24: Closer view of site from the west	22
Figure 25: Closer view of site from the north	22
Figure 26: Closer view of site from the east	23
Figure 27: Closer view of site from Clonliffe Road	23
Figure 28: Closer view Courtyard of HJL Block B1 and MCM Extension	24
Figure 29: Closer view of OMP Block A1 courtyard	24
Figure 30: Closer view of HJL Block D2 Courtyard	25
Figure 31: Closer view of ODT D1 tower from south	25
Figure 32: Closer view of ODT D1 tower from west	26
Figure 33: Closer view of ODT D1 tower from north	26
Figure 34: Closer view of ODT D1 tower from east	27
Figure 35: Sitting Comfort Criteria: Overall Site	29
Figure 36: Sitting Comfort Criteria: OMP Blocks A1 to A4	30
Figure 37: Sitting Comfort Criteria: HJL Block B1 and MCM Extension	31
Figure 38: Sitting Comfort Criteria: HJL Blocks B2 and B3	32
Figure 39: Sitting Comfort Criteria: HJL Block C1	33
Figure 40: Sitting Comfort Criteria: HJL Block C2	34
Figure 41: Sitting Comfort Criteria: ODT Block D1	35
Figure 42: Sitting Comfort Criteria: HJL Block D2	36
Figure 43: Standing Comfort Criteria: Overall Site	37
Figure 44: Standing Comfort Criteria: OMP Blocks A1 to A4	38
Figure 45: Standing Comfort Criteria: HJL Block B1 and MCM Extension	39



Figure 46: Standing Comfort Criteria: HJL Blocks B2 and B3	40
Figure 47: Standing Comfort Criteria: HJL Block C1	41
Figure 48: Standing Comfort Criteria: HJL Block C2	42
Figure 49: Standing Comfort Criteria: ODT Block D1	43
Figure 50: Standing Comfort Criteria: HJL Block D2	44
Figure 51: Leisure Walking Comfort Criteria: Overall Site	45
Figure 52: Leisure Walking Comfort Criteria: OMP Blocks A1 to A4	46
Figure 53: Leisure Walking Comfort Criteria: HJL Block B1 and MCM Extension	47
Figure 54: Leisure Walking Comfort Criteria: HJL Blocks B2 and B3	48
Figure 55: Leisure Walking Comfort Criteria: HJL Block C1	49
Figure 56: Leisure Walking Comfort Criteria: HJL Block C2	50
Figure 57: Leisure Walking Comfort Criteria: ODT Block D1	51
Figure 58: Leisure Walking Comfort Criteria: HJL Block D2	52
Figure 59: Business Walking Comfort Criteria: Overall Site	53
Figure 60: Business Walking Comfort Criteria: OMP Blocks A1 to A4	54
Figure 61: Business Walking Comfort Criteria: HJL Block B1 and MCM Extension	55
Figure 62: Business Walking Comfort Criteria: HJL Blocks B2 and B3	56
Figure 63: Business Walking Comfort Criteria: HJL Block C1	57
Figure 64: Business Walking Comfort Criteria: HJL Block C2	58
Figure 65: Business Walking Comfort Criteria: ODT Block D1	59
Figure 66: Business Walking Comfort Criteria: HJL Block D2	60
Figure 67: e Criteria: Overall Site	61
Figure 68: Normal Pedestrian Safety Criteria: OMP Blocks A1 to A4	62
Figure 69: Normal Pedestrian Safety Criteria: HJL Block B1 and MCM Extension	63
Figure 70: Normal Pedestrian Safety Criteria: HJL Blocks B2 and B3	64
Figure 71: Normal Pedestrian Safety Criteria: HJL Block C1	65
Figure 72: Normal Pedestrian Safety Criteria: HJL Block C2	66
Figure 73: Normal Pedestrian Safety Criteria: ODT Block D1	67
Figure 74: Normal Pedestrian Safety Criteria: HJL Block D2	68
Figure 75: Sensitive Pedestrian Safety Criteria: Overall Site	69
Figure 76: Sensitive Pedestrian Safety Criteria: OMP Blocks A1 to A4	70
Figure 77: Sensitive Pedestrian Safety Criteria: HJL Block B1 and MCM Extension	71
Figure 78: Sensitive Pedestrian Safety Criteria: HJL Blocks B2 and B3	72
Figure 79: Sensitive Pedestrian Safety Criteria: HJL Block C1	73
Figure 80: Sensitive Pedestrian Safety Criteria: HJL Block C2	74
Figure 81: Sensitive Pedestrian Safety Criteria: ODT Block D1	75
Figure 82: Sensitive Pedestrian Safety Criteria: HJL Block D2	76

1 Executive Summary

IES Consulting have been commissioned to investigate the potential impact of wind movement on pedestrian comfort around the Holy Cross College SHD development in Drumcondra, Dublin, proposed by CWTC Multi Family ICAV acting on behalf of its sub-fund DBTR DR1 Fund

The development will consist of the construction of a Build To Rent residential development set out in 12 no. blocks, ranging in height from 3 to 18 storeys, to accommodate 1614 no. apartments (comprising 540 studios, 602 no. 1 bed units, 419 no. 2 bed units and 53 no. 3 bed units) including a retail unit, a café unit, a crèche, and residential tenant amenity spaces. The development will include a single level basement under Blocks B2, B3 & C1, a single level basement under Block D2 and a podium level and single level basement under Block A1 to accommodate car parking spaces, bicycle parking, storage, services and plant areas.

For the analysis, 8 steady state CFD simulations were performed for the main wind directions (N, NE, E, SE, S, SW, W and NW) and annual average wind speed for Casement Aerodrome near Dublin. The wind was assumed to have characteristics associated with wind flowing through a suburb. The results obtained from the simulations were extrapolated along the annual weather data to obtain the most probable local air speed for each hour of the year. Statistical analysis was performed on this dataset to check compliance against the Lawson's Pedestrian Comfort criterion.

The following table provides values for the Lawson's pedestrian comfort assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

The following table provides values for Lawson's Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum ² (m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

The value in each criterion will be the corresponding air speed as noted in the Lawson's comfort criterion as shown in [section 5.1](#). The results images report contour plots of percentage of time the air speed exceeds a particular value in [section 7](#). From the image scale the following can be surmised:

Colour	Observation
Green	Comfort criterion achieved
Yellow	Marginal non-compliance, minor mitigation measures required
Orange	Marginal non-compliance, medium mitigation measures required
Red	Non-compliance, major mitigation measures required

1.1 Sitting and Standing Comfort

The Lawson's sitting comfort criteria states that the local air speed at designated locations should not exceed 4m/s for more than 5% of the year (~18 days). The Lawson's standing comfort criteria states that the local air speed at designated locations should not exceed 6m/s for more than 5% of the year.

The median wind speed in Dublin is between 4-5 m/s. That means, for 50% of year, the wind speed is higher.

The Lawson's Sitting Comfort Criterion (where all the yellow-red areas are seen) requires the local air speed to be less than 4m/s for more than 95% of the year, when for 50% of the year the wind speed is higher. The Lawson's Standing Comfort Criterion requires the local air speed to be less than 6m/s for more than 95% of the year.

1.1.1 Ground Level

As observed in [section 7.1.1.1](#), and [section 7.1.2.1](#), the site shows generally good compliance with the sitting criterion and standing criterion on the grounds around the site.

There are a few locations where the strict adherence to sitting criterion was exceeded (seen in [section 7.1.1.1](#)).

- i) Public open space between Blocks C2 and D1,
- ii) Public open space between Blocks B3 and D1,
- iii) Public open space between Blocks A1 and A2/A3, and
- iv) Public open space north of block A3.

However, on comparing the results on these locations to standing criterion results ([section 7.1.2.1](#)), it can be seen that all these locations show excellent compliance with the standing criterion.

The proposed location of café at base of tower D1 also shows good results for sitting and standing criteria. See [Figure 41](#), and [Figure 49](#).

The wind speed threshold for sitting criterion is 4m/s. The same threshold for standing criterion is 6m/s. So whenever the wind speed at the above location exceeds 4m/s, it is also very much likely to be less than 6m/s. So any exceedance noted can be considered very marginal and subjective to individual preferences. It will not lead to an environment which is unpleasant to use.

1.1.2 Balconies

All balconies on the site other than the balconies of the D1 Block show excellent compliance with the sitting criterion and standing criterion. The recessed nature of the balconies helps to keep the air speed low on the balconies.

The balconies of the Block D1 can be seen in [section 7.1.1.7](#). The balconies of Block D1 show excellent compliance with the standing criterion results. So, similarly to the ground level results discussed above, whenever the sitting comfort criterion is exceeded (air speed > 4 m/s), the air speed will likely be < 6 m/s (standing comfort criterion threshold). So the exceedance noted can be classed as only marginal, and will not lead to an environment which is unpleasant to use. The environment on these balconies will be typical of, and consistent with, balconies on buildings of a similar scale and design.

1.1.3 Roof Top Communal Spaces

The sitting comfort results for rooftop communal spaces can be observed in [section 7.1.1.2](#) and [section 7.1.1.7](#). The standing comfort results for the same locations can be observed in [section 7.1.2.2](#) and [section 7.1.2.7](#).

As observed above in relation to ground level and balconies, the sitting comfort criterion results show some exceedance over the recommended levels at the roof top communal spaces. However, the standing criterion results show excellent compliance. Again, whenever the sitting comfort criterion is exceeded (air speed > 4 m/s), the air speed will likely be < 6 m/s (standing comfort criterion threshold). So the exceedance noted can be classed as only marginal, and will not lead to an environment which is unpleasant to use. The environment on these rooftop spaces will be typical of, and consistent with, rooftop spaces on buildings of a similar scale and design.

1.2 Walking Comfort

The Lawson's Leisure Walking and Business Walking comfort criteria states that the local air speed at designated locations should not exceed 8m/s and 10m/s respectively for more than 5% of the year.

The results for this can be observed in [section 7.1.3](#) and [section 7.1.4](#) respectively. The site shows excellent compliance with the requirements of both the criteria.

1.3 Safety Criteria

The Lawson's Normal Pedestrian and Sensitive Pedestrian Safety criteria states that the local air speed at designated locations should not exceed 20m/s and 15m/s respectively for more than 0.01% of the year i.e. only 1 hour of the year.

Despite such a severe requirement, the site shows excellent compliance with both the safety criteria.

2 Development Description

The development will consist of the construction of a Build To Rent residential development set out in 12 no. blocks, ranging in height from 2 to 18 storeys, to accommodate 1614 no. apartments including a retail unit, a café unit, a crèche, and residential tenant amenity spaces. The development will include a single level basement under Blocks B2, B3 & C1, a single level basement under Block D2 and a podium level and single level basement under Block A1 to accommodate car parking spaces, bicycle parking, storage, services and plant areas. To facilitate the proposed development the scheme will involve the demolition of a number of existing structures on the site.

The proposed development sits as part of a wider Site Masterplan for the entire Holy Cross College lands which includes a permitted hotel development and future proposed GAA pitches and clubhouse.

The site contains a number of Protected Structures including The Seminary Building, Holy Cross Chapel, South Link Building, The Assembly Hall and The Ambulatory. The application proposes the renovation and extension of the Seminary Building to accommodate residential units and the renovation of the existing Holy Cross Chapel and Assembly Hall buildings for use as residential tenant amenity. The wider Holy Cross College lands also includes Protected Structures including The Red House and the Archbishop's House (no works are proposed to these Structures).

The residential buildings are arranged around a number of proposed public open spaces and routes throughout the site with extensive landscaping and tree planting proposed. Communal amenity spaces will be located adjacent to residential buildings and at roof level throughout the scheme. To facilitate the proposed development the scheme will involve the removal of some existing trees on the site.

The site is proposed to be accessed by vehicles, cyclists and pedestrians from a widened entrance on Clonliffe Road, at the junction with Jones's Road and through the opening up of an unused access point on Drumcondra Road Lower at the junction with Hollybank Rd. An additional cyclist and pedestrian access is proposed through an existing access point on Holy Cross Avenue. Access from the Clonliffe Road entrance will also facilitate vehicular access to future proposed GAA pitches and clubhouse to the north of the site and to a permitted hotel on Clonliffe Road.

The proposed application includes all site landscaping works, green roofs, boundary treatments, PV panels at roof level, ESB Substations, lighting, servicing and utilities, signage, and associated and ancillary works, including site development works above and below ground.

3 Weather Data

The analysis is based on the 'DublinIWEC.epw' weather file. The variation of wind speed recorded in the weather file is shown in figure 1 below. Figure 2 shows the wind direction variation and Figure 3 shows the wind rose.

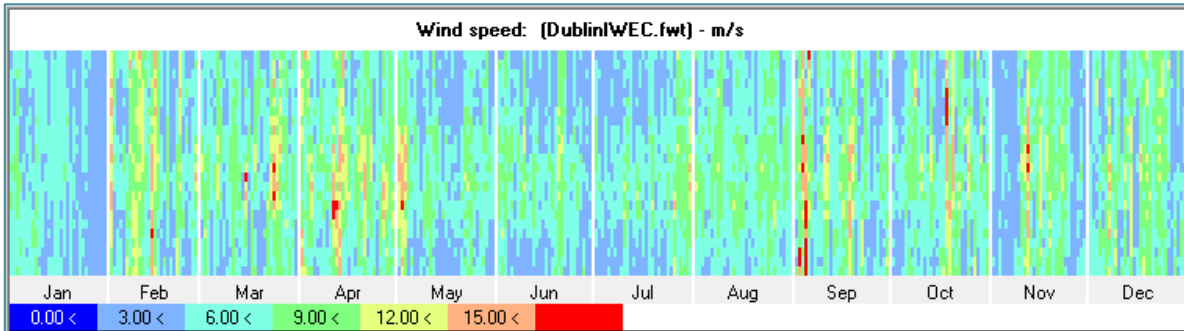


Figure 1: Wind speed variation as per DublinIWEC.epw

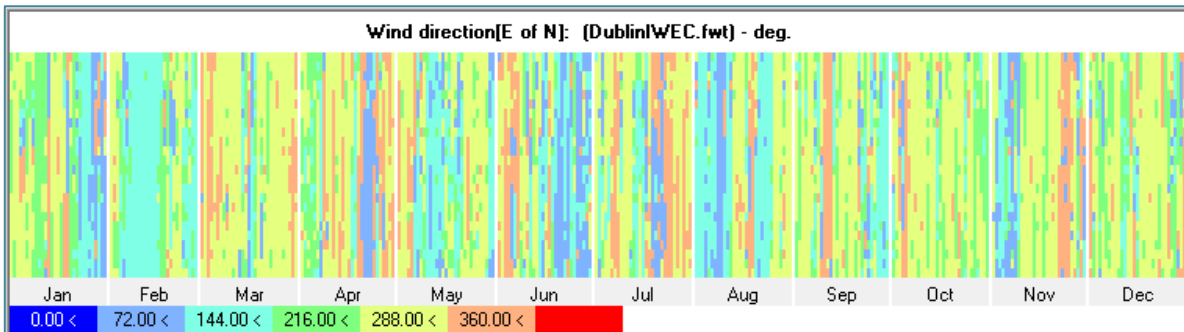


Figure 2: Wind direction variation as per DublinIWEC.epw

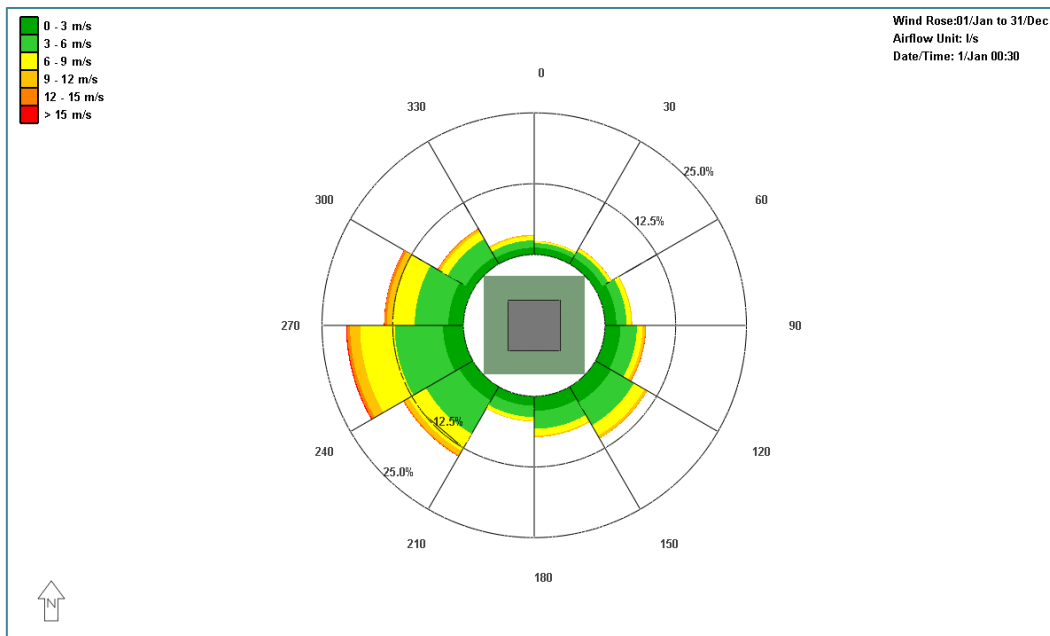


Figure 3: Wind rose as per DublinIWEC.epw

Based on this, the mean wind speed recorded was 5m/s with a westerly prevailing direction.

4 Wind Boundary Layer

In an atmospheric boundary layer, wind speed increases with height due to the influence of surface roughness (i.e. the presence of buildings, trees, roads etc. on the ground), see Figure 4.

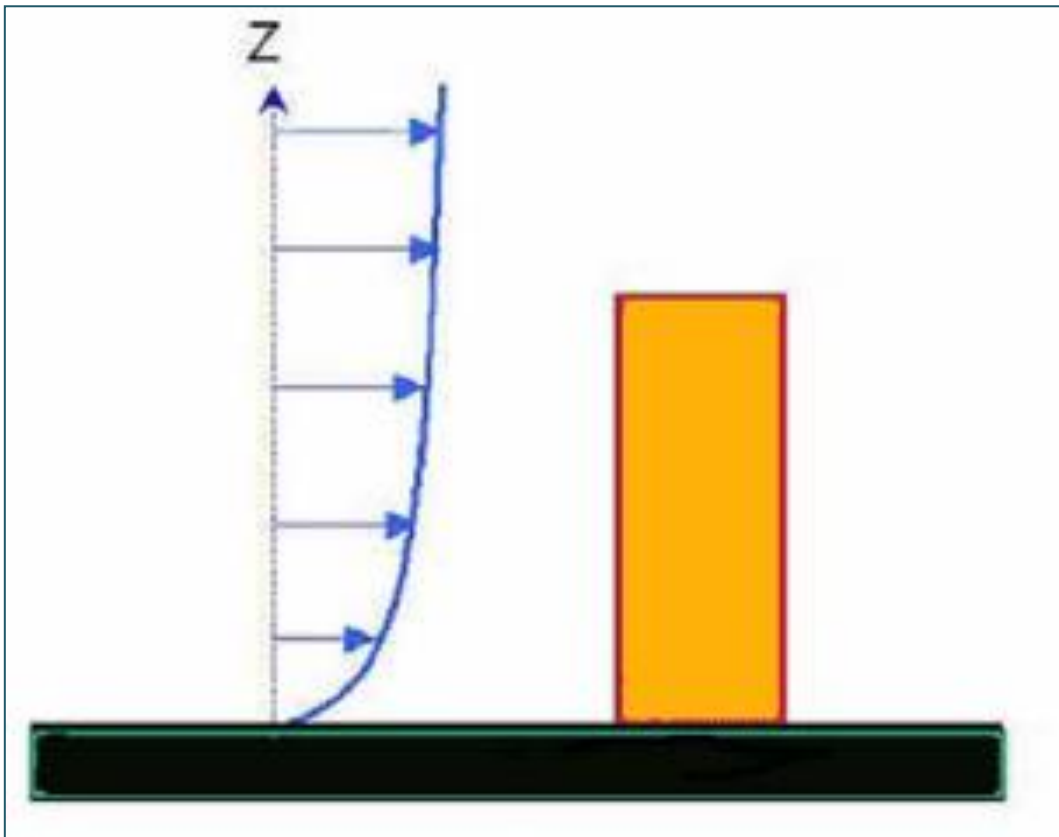


Figure 4: Typical velocity profile of an atmospheric boundary layer

In the current CFD modelling, the velocity profile was generated according to the parameterised ASHRAE methodology described below. This allows for different wind profiles across various terrain types: Open country; urban; and city centre.

The wind speed U_H at height H above the ground is given by:

$$U_H = U_{met} \left(\frac{\delta_{met}}{H_{met}} \right)^{a_{met}} \left(\frac{H}{\delta} \right)^a \dots \dots \dots (Eq. 1)$$

Where,

- a = Exponent in power law wind speed profile for local building terrain
- δ = fully developed strong wind atmospheric boundary layer thickness (m)
- a_{met} = Exponent for the meteorological station
- δ_{met} = Atmospheric boundary thickness at the meteorological station (m)
- H_{met} = Height at which meteorological wind speed was measured (m)
- U_{met} = Hourly meteorological wind speed, measured at height H_{met} (m/s)

The parameters for different types of terrain are given as in table 1.

Table 1: Atmospheric boundary layer parameters

Terrain Category	Description	a	δ
1	Large city centres 50% of buildings above 21m over a distance of at least 2000m upwind.	0.33	460
2	Urban, suburban, wooded areas.	0.22	370
3	Open, with scattered objects generally less than 10m high.	0.14	270
4	Flat, unobstructed areas exposed to wind flowing over a large water body (no more than 500m inland).	0.10	210

For the current project, we used the atmospheric boundary layer corresponding to the terrain category 1 i.e. large city centres type of site. The met data was taken on category 3 terrain at a height of 10m. Figure 5 below shows the shape of the wind boundary profile.

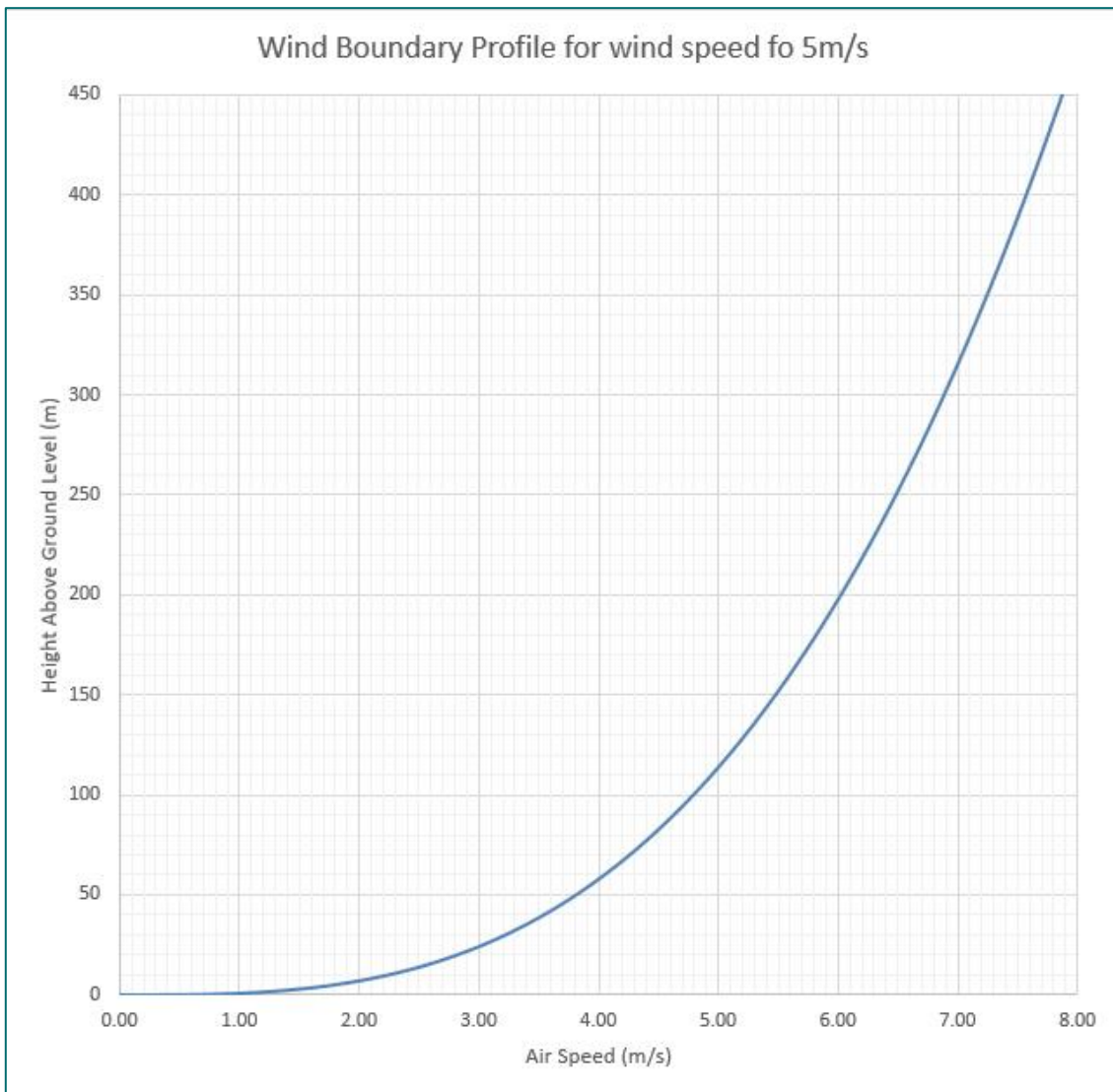


Figure 5: Wind boundary profile for the CFD simulations using annual average wind speed

5 Methodology for Pedestrian Comfort Calculation

The methodology for the analysis was as follows:

- 1) The annual mean wind speed was determined from the 'DublinIWEC.epw' weather file.
- 2) 8 steady state CFD simulations were performed corresponding to the 8 directions – SW, W, NW, N, NE, E, SE and S respectively.
- 3) The local air speed at various designated locations around the site was recorded for each of the simulations.
- 4) This value was compared to the meteorological wind speed used and the magnification factor at that location for the corresponding wind direction was determined.
- 5) The magnification factor was used to determine the air speed at the designated locations for the various recorded values of the wind speed and direction in the weather file, thus generating the local air speeds at designated locations for a year.
- 6) These recorded values were compared to the Lawson Pedestrian Comfort/Safety Criteria.

5.1 Lawson Pedestrian Comfort/Safety Criteria

The Lawson Criteria¹ was used as a reference to assess the wind effects. It is the most widely used reference for assessment of pedestrian comfort. It considers the air speed at the location as well as the frequency of the occurrence of this air speed. It consists of two assessment criteria:

1. The first criteria assess whether the air movement will be comfortable for the pedestrian for different types of activities.
2. The second criteria assess the feeling of safety or distress by the pedestrian at higher air speeds.

Following table gives the values for the Lawson's pedestrian comfort assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

Following table gives the values for Lawson's Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum ² (m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

¹T. V. Lawson (2001) *Building Aerodynamics*, Imperial College Press, London.

²Once per annum means the safety threshold is not be exceeded 0.01% of the year.

6 CFD Model

The CFD model was created based on the CAD drawings provided.

6.1 Model Geometry

Figures 22 to 50 show the geometry as modelled.



Figure 6: Plan view of the site

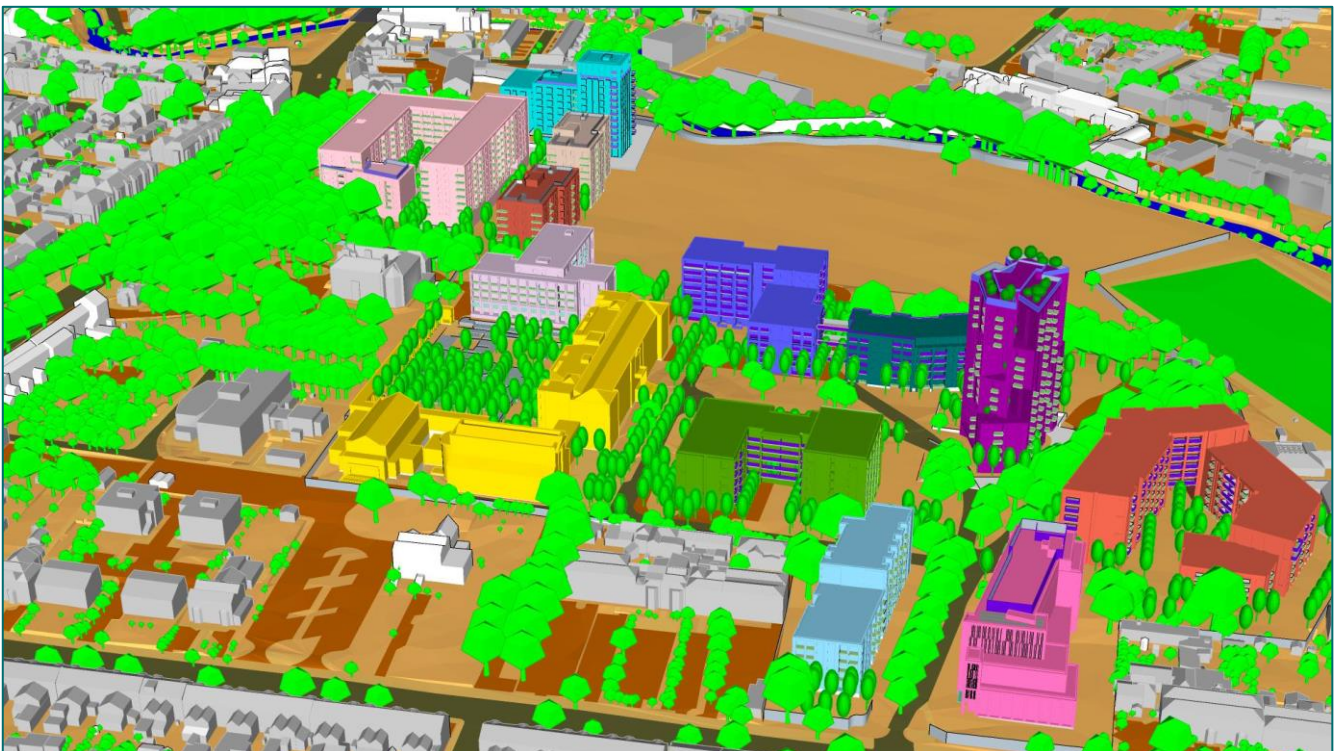


Figure 7: View of the site from the south

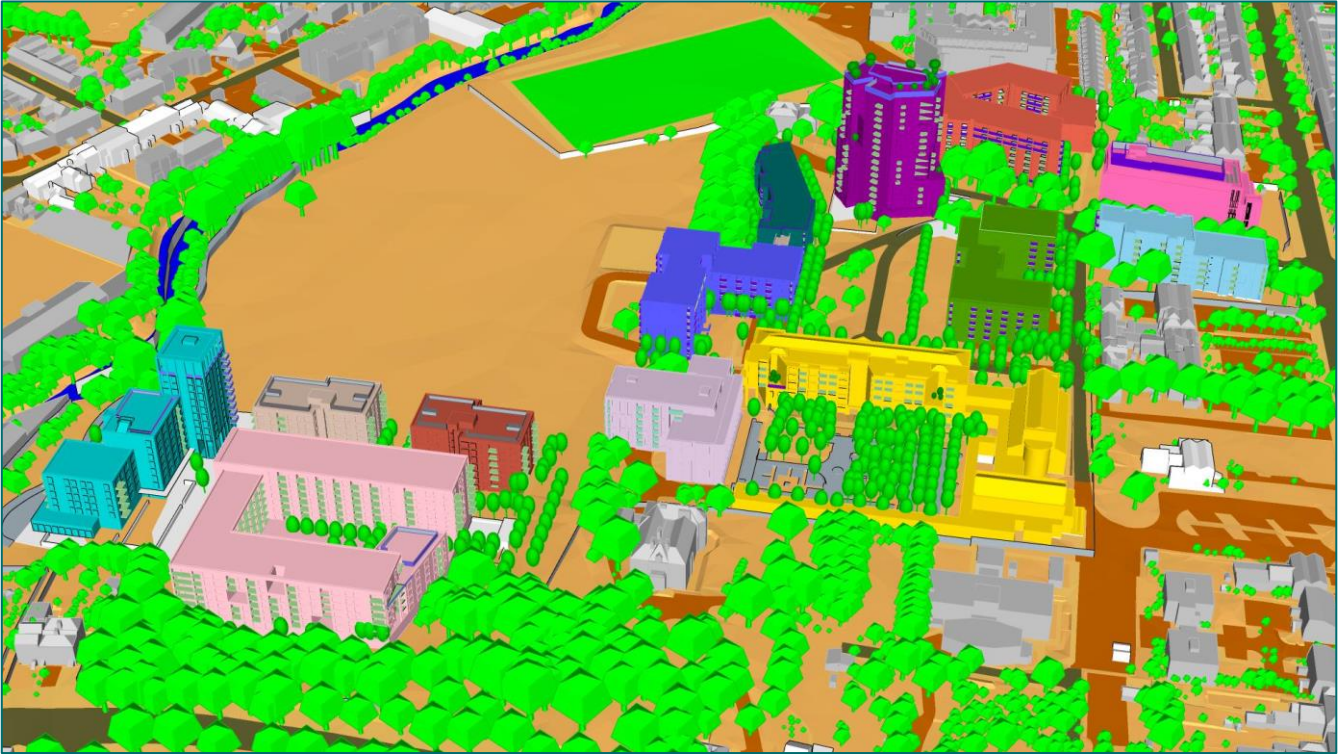


Figure 8: View of the site from the west



Figure 9: View of the site from the north

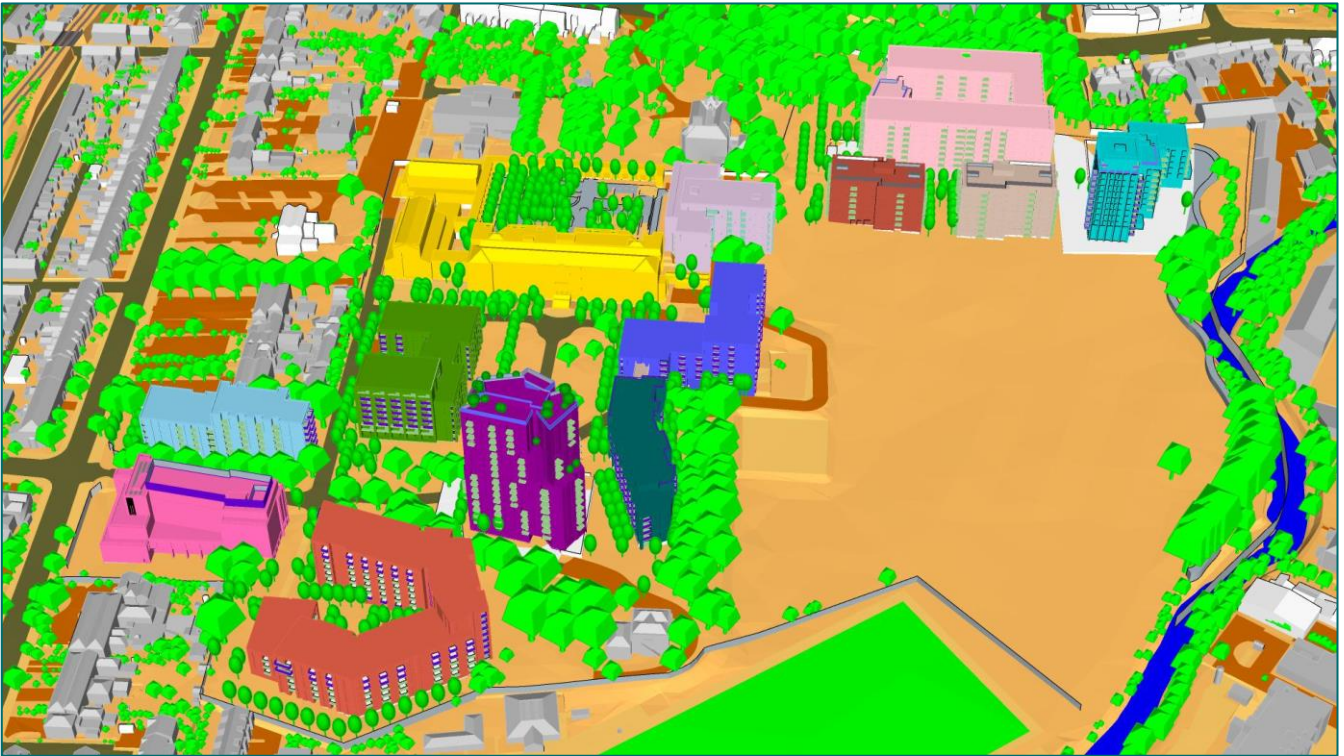


Figure 10: View of the site from the east

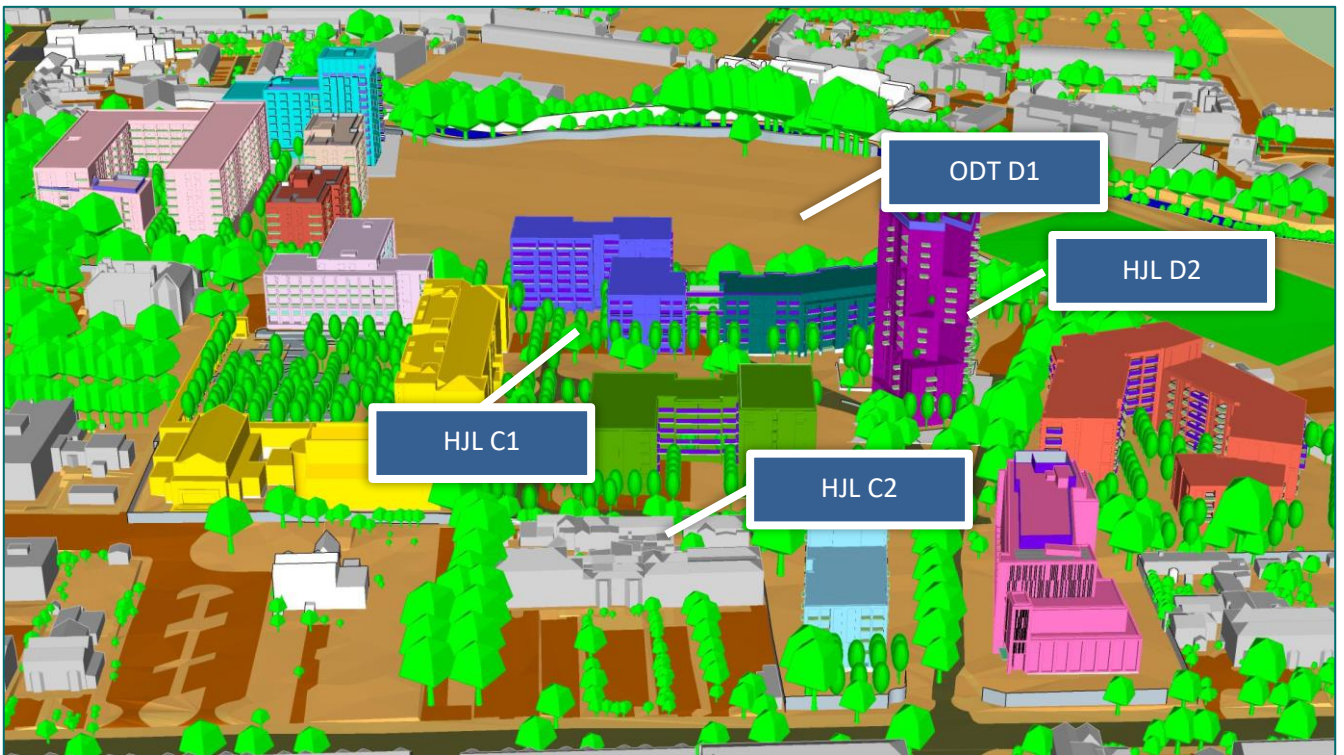


Figure 11: Closer view of site from the south

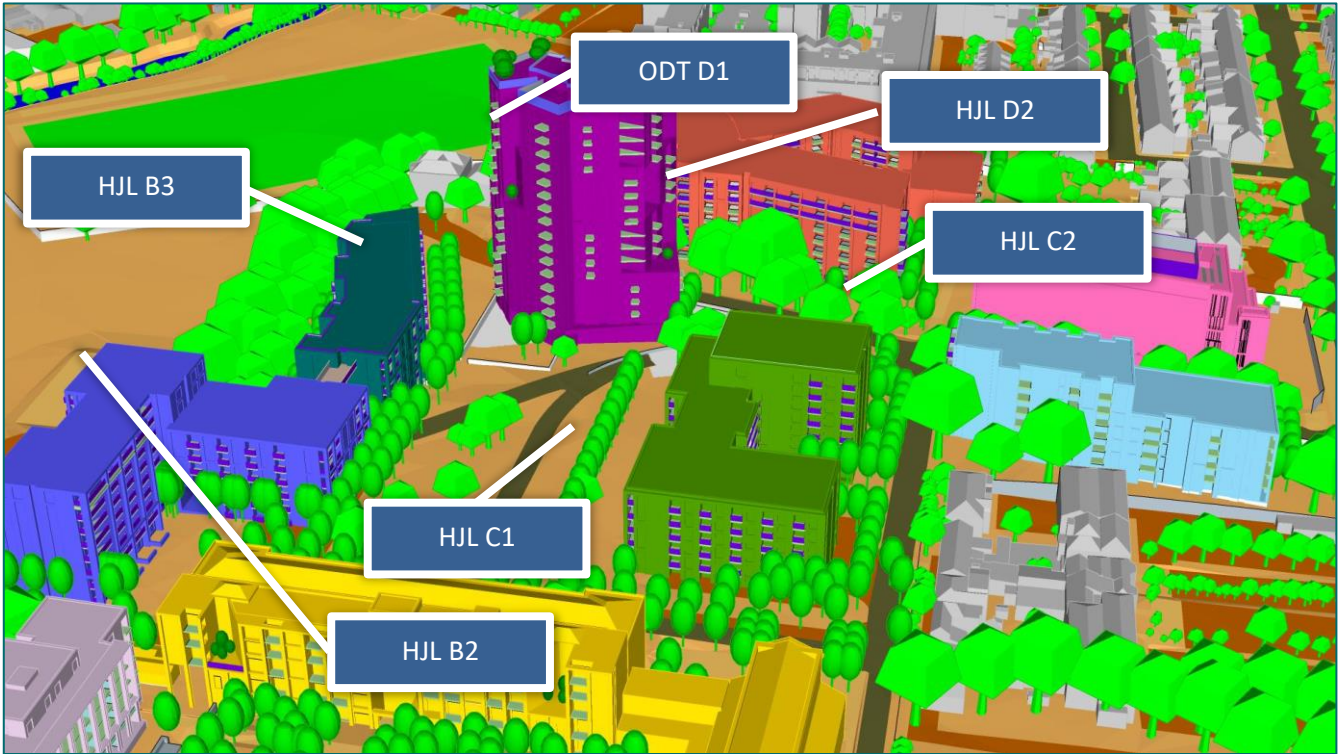


Figure 12: Closer view of site from the west



Figure 13: Closer view of site from the north



Figure 14: Closer view of site from the east



Figure 15: Closer view of site the South



Figure 16: Closer view of site from the west



Figure 17: Closer view of site from the north



Figure 18: Closer view of site from the east

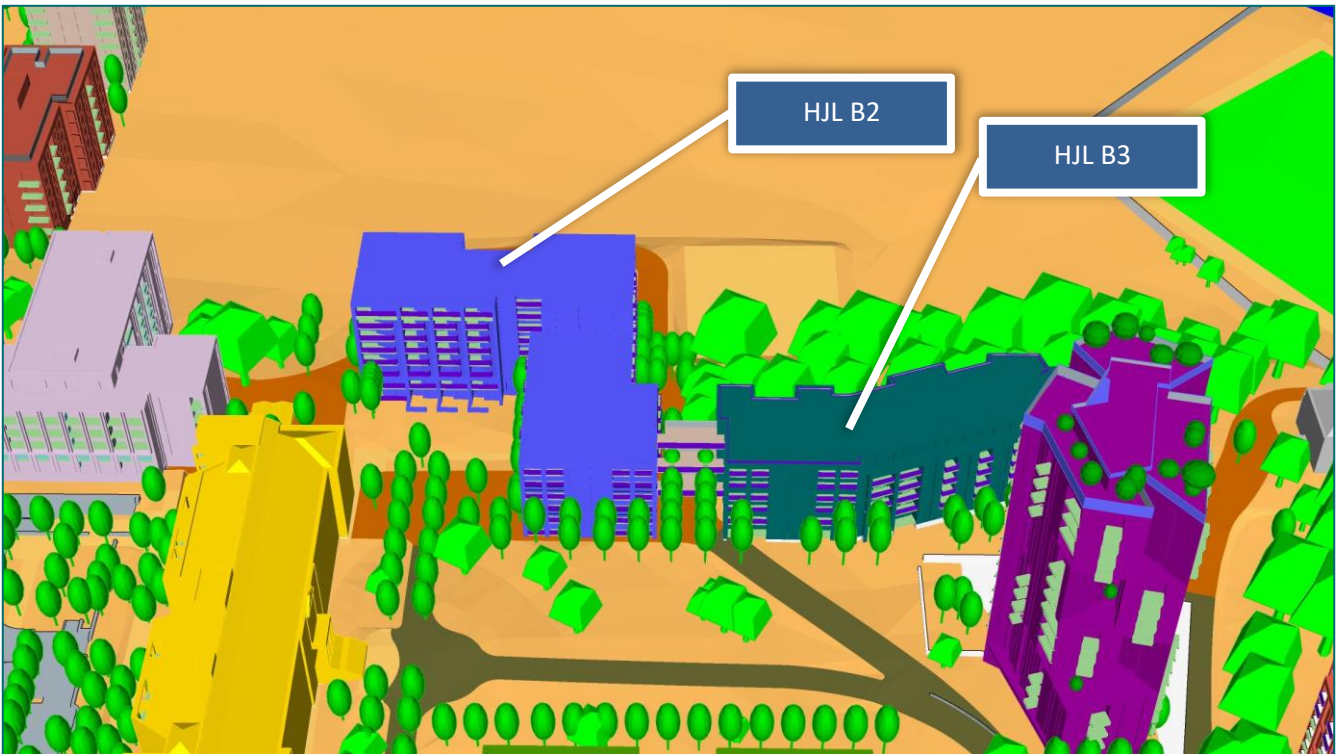


Figure 19: Closer view of site from the South

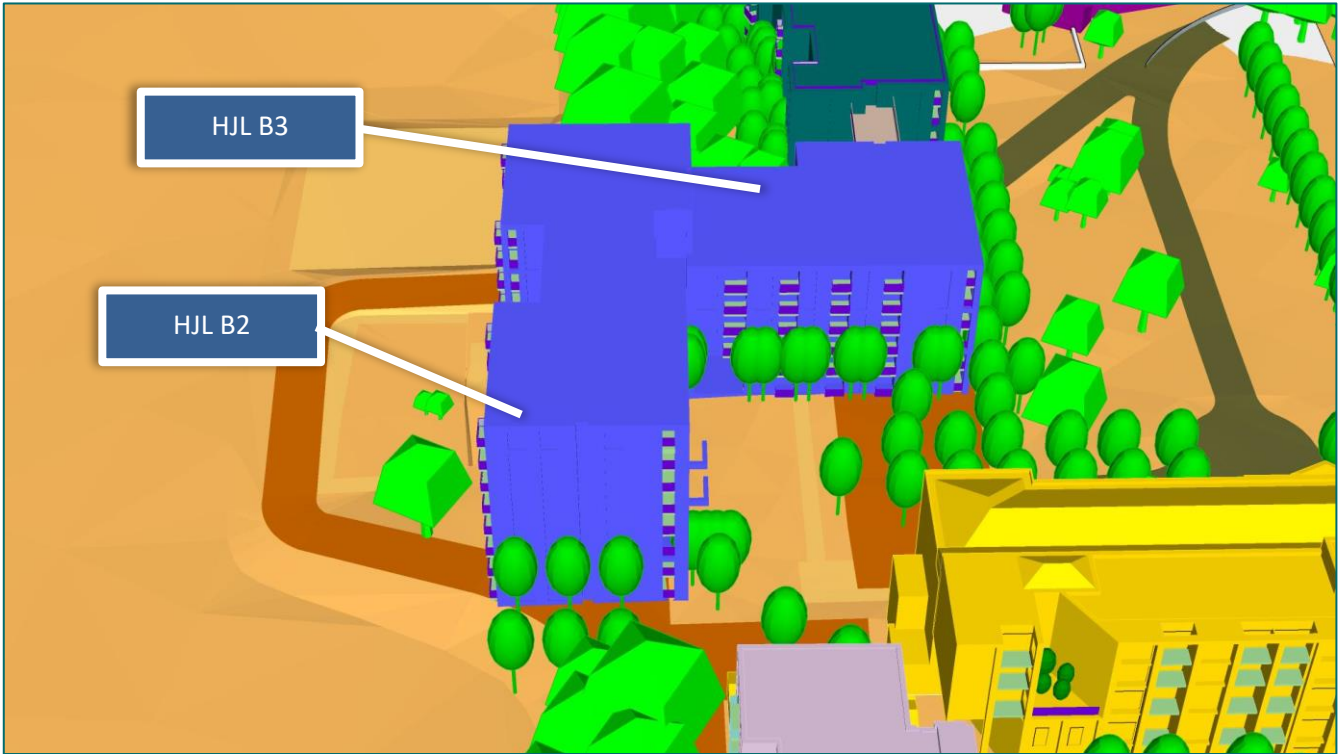


Figure 20: Closer view of site from the West

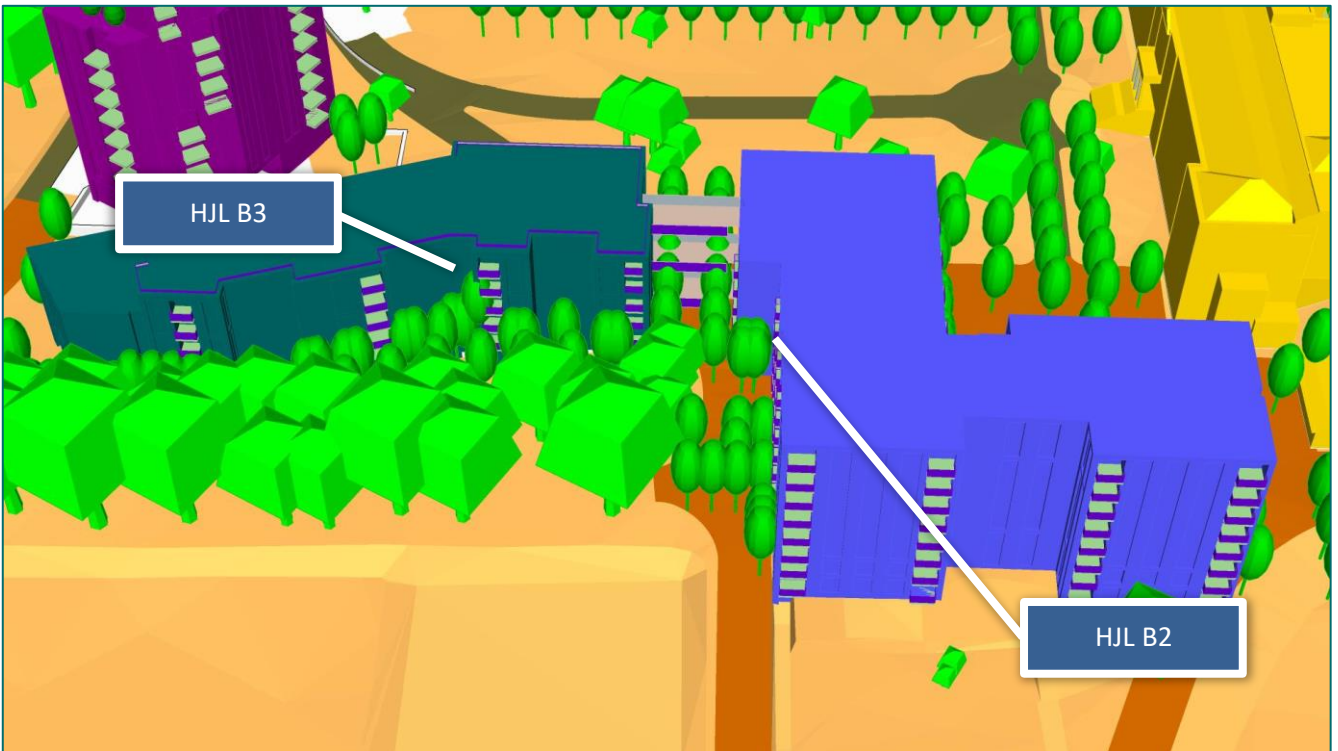


Figure 21: Closer view of site from the North



Figure 22: Closer view site from east

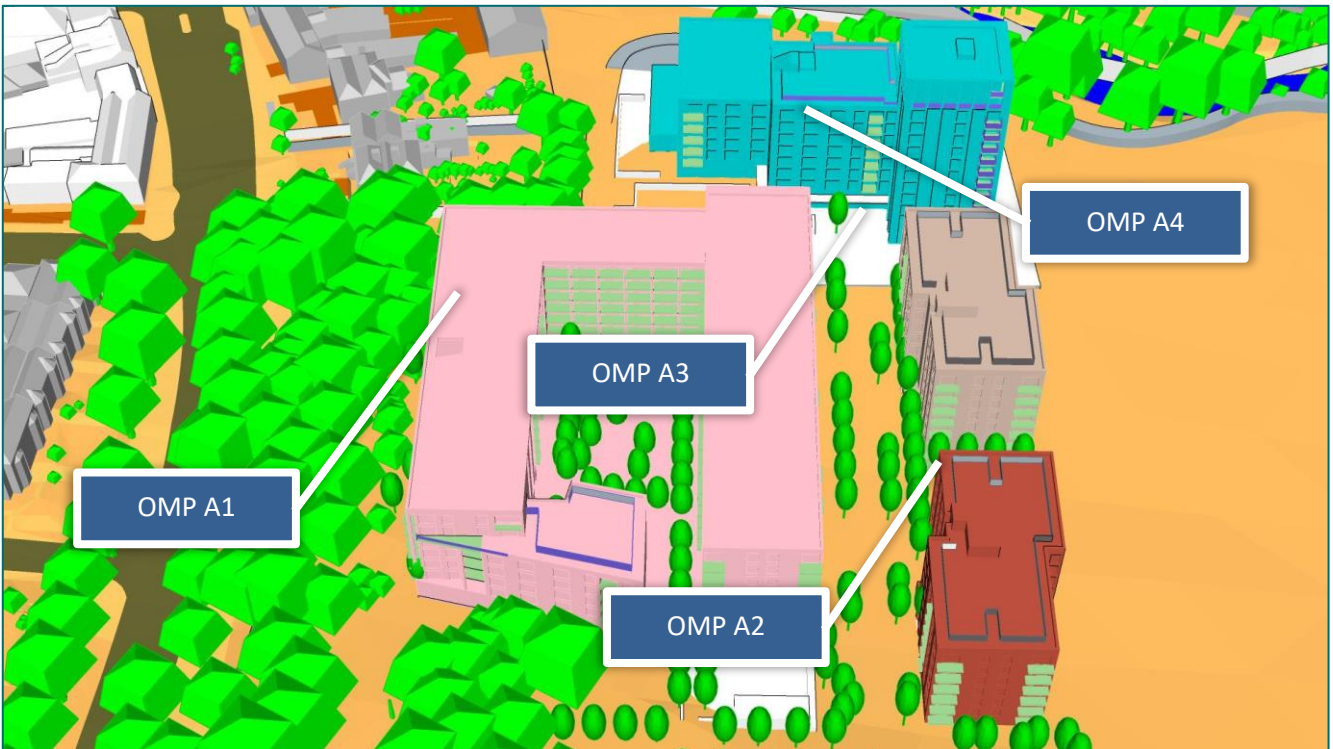


Figure 23: Closer view site from the south

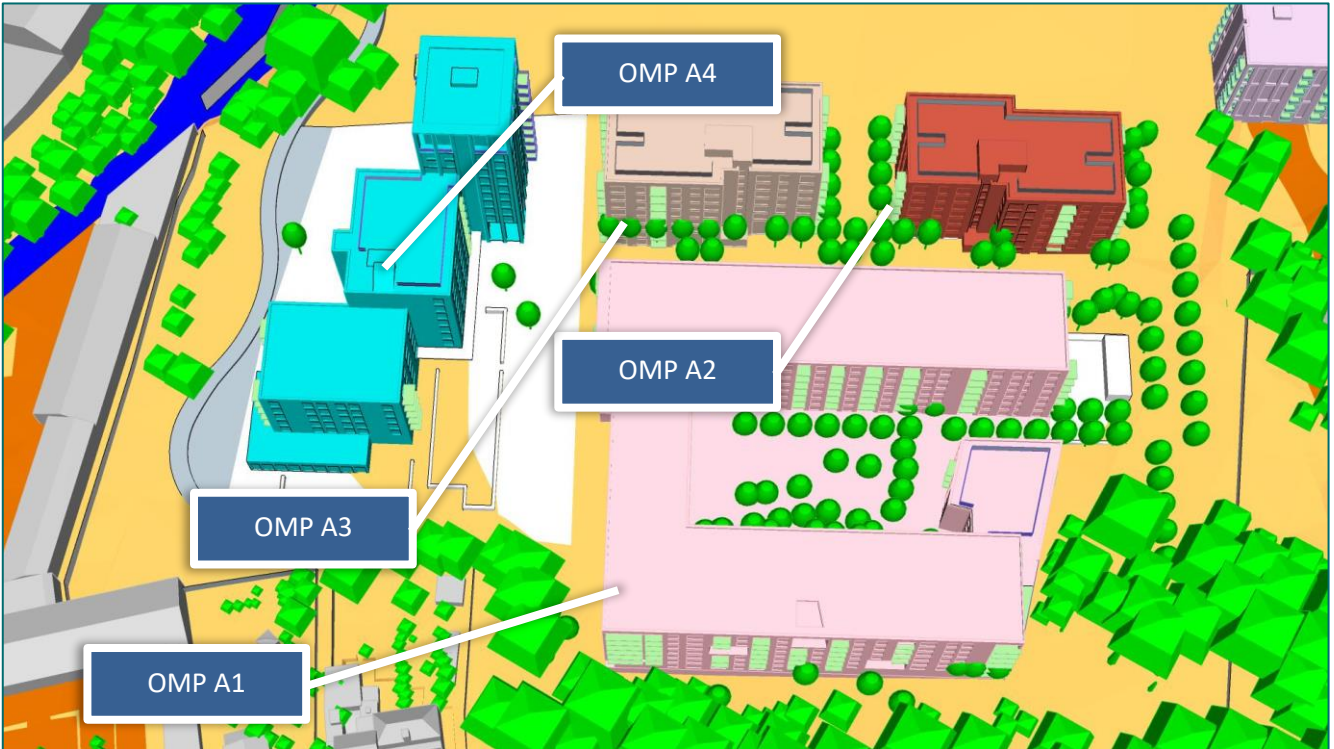


Figure 24: Closer view of site from the west



Figure 25: Closer view of site from the north



Figure 26: Closer view of site from the east

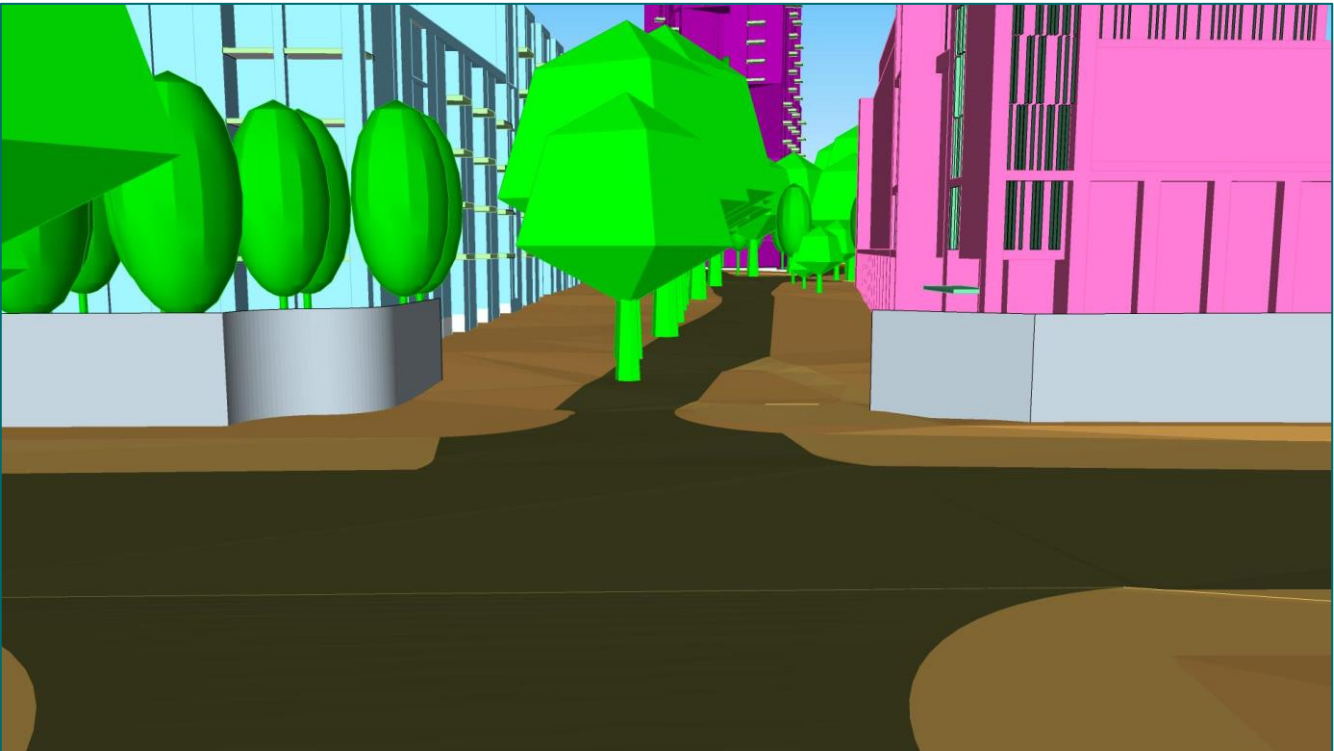


Figure 27: Closer view of site from Clonliffe Road



Figure 28: Closer view Courtyard of HJL Block B1 and MCM Extension

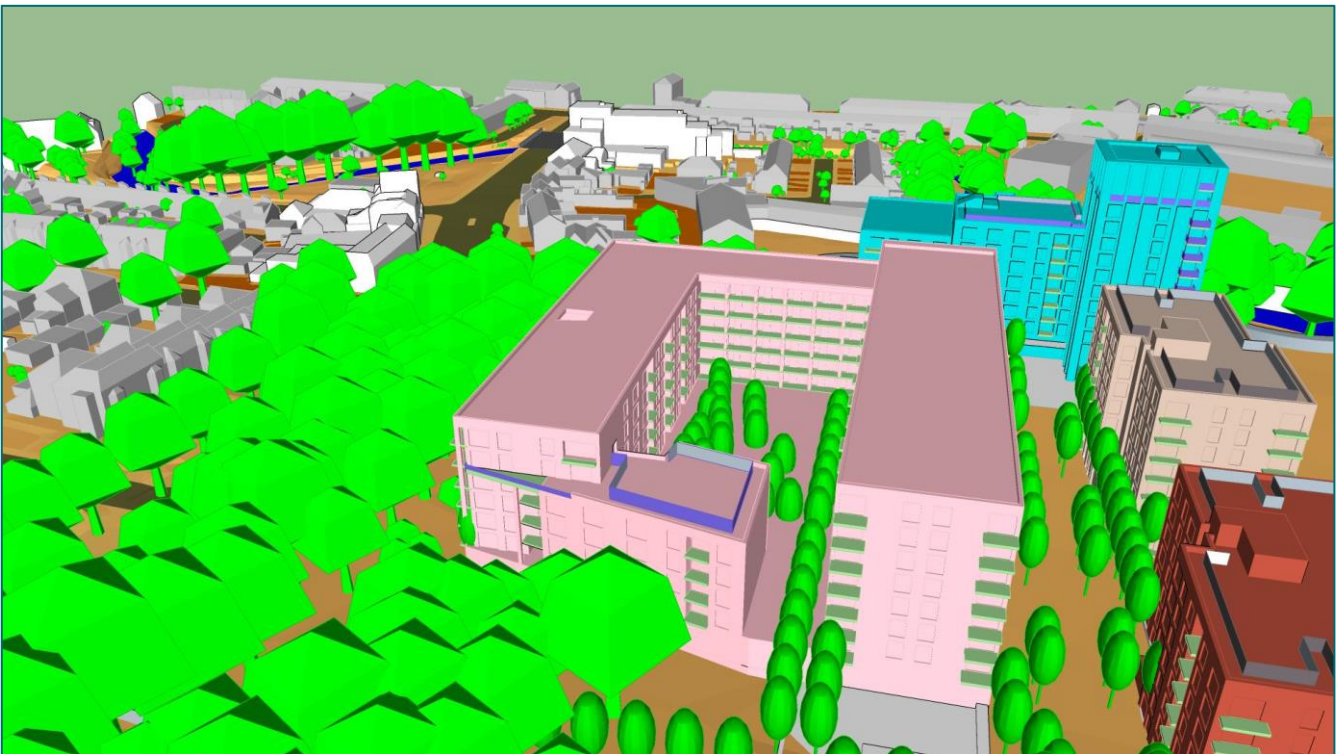


Figure 29: Closer view of OMP Block A1 courtyard

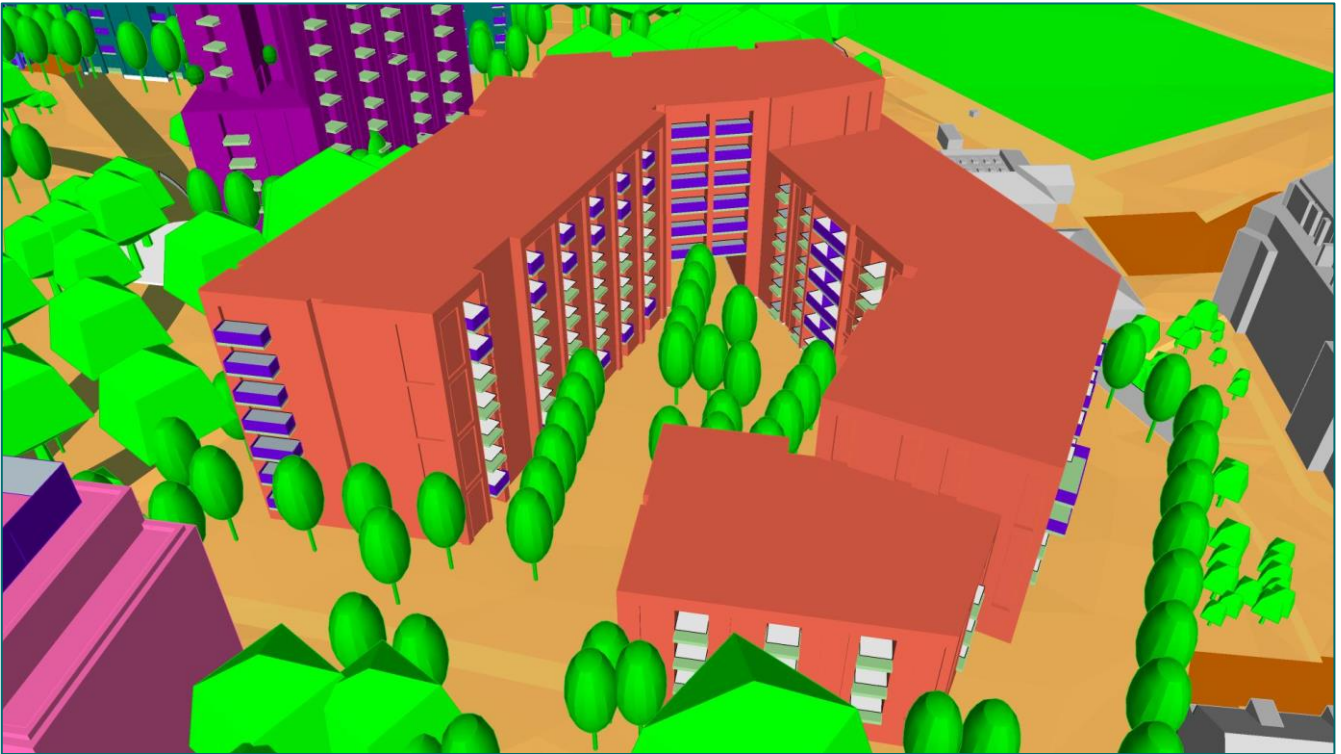


Figure 30: Closer view of HJL Block D2 Courtyard

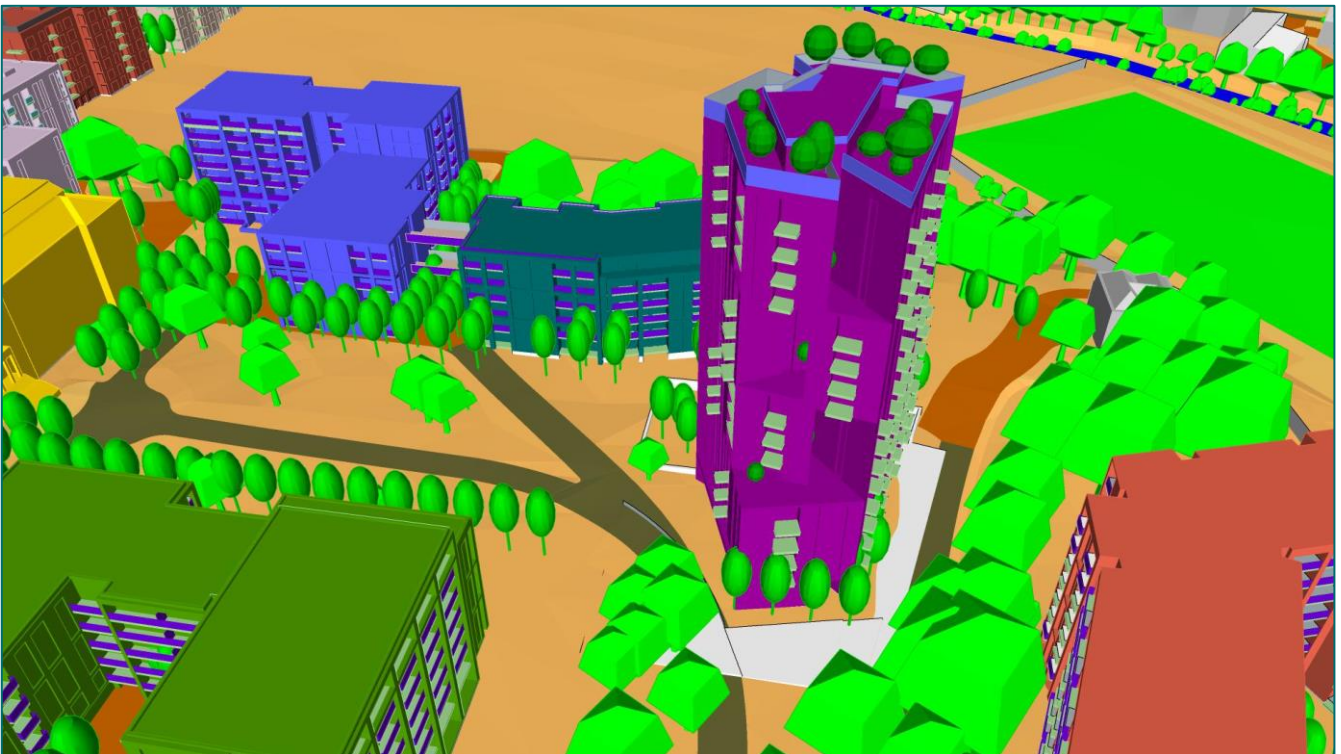


Figure 31: Closer view of ODT D1 tower from south

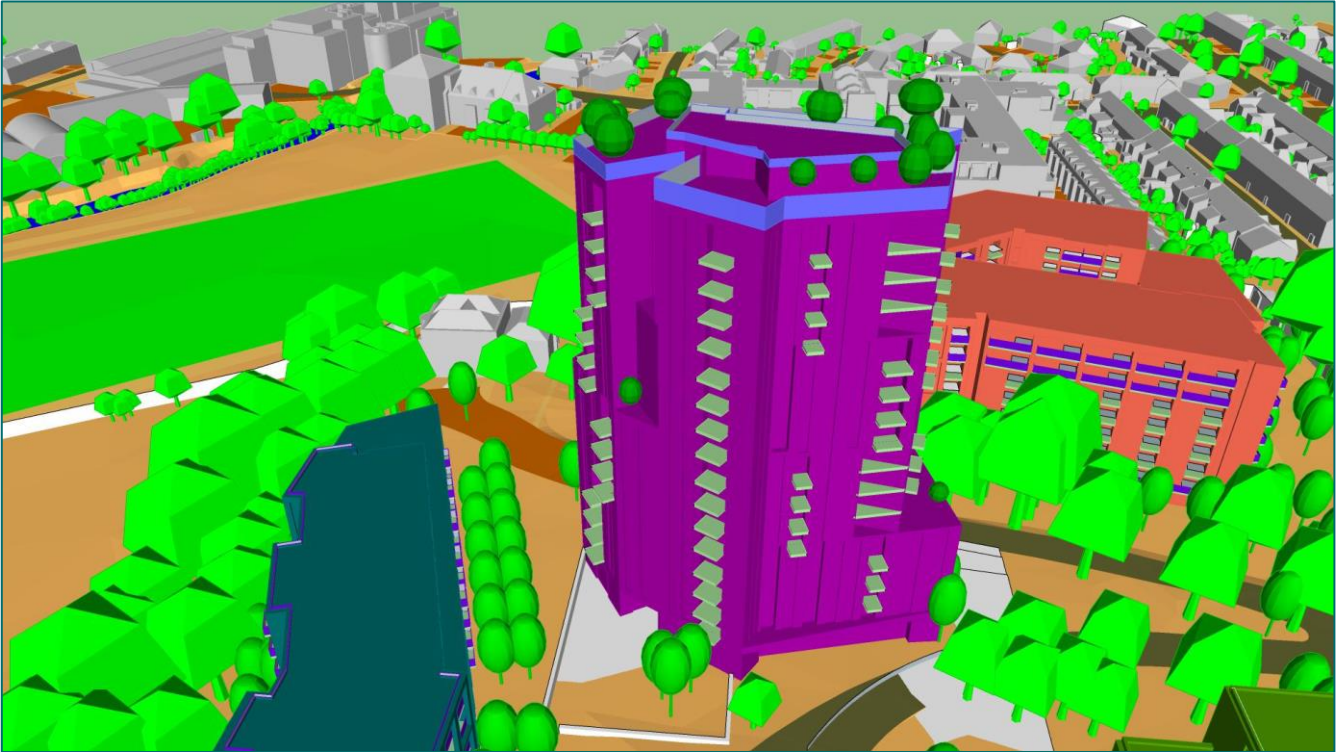


Figure 32: Closer view of ODT D1 tower from west

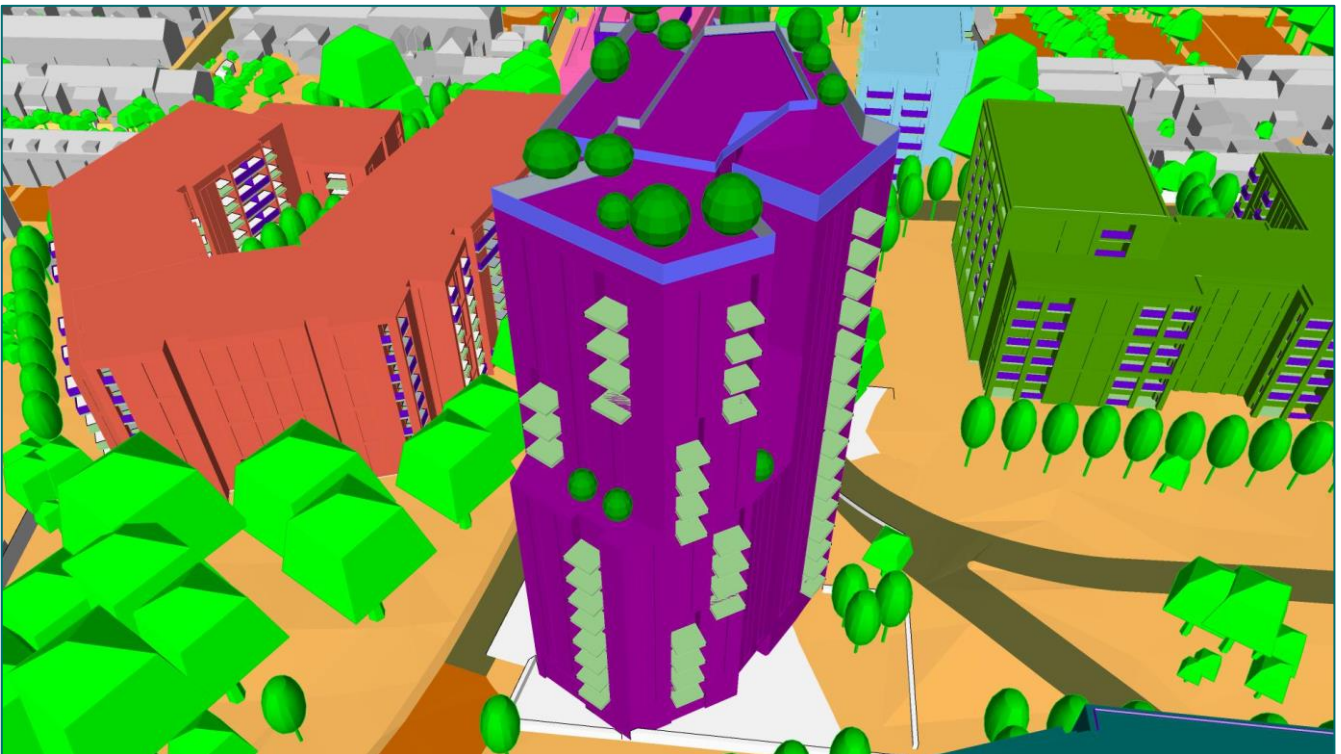


Figure 33: Closer view of ODT D1 tower from north

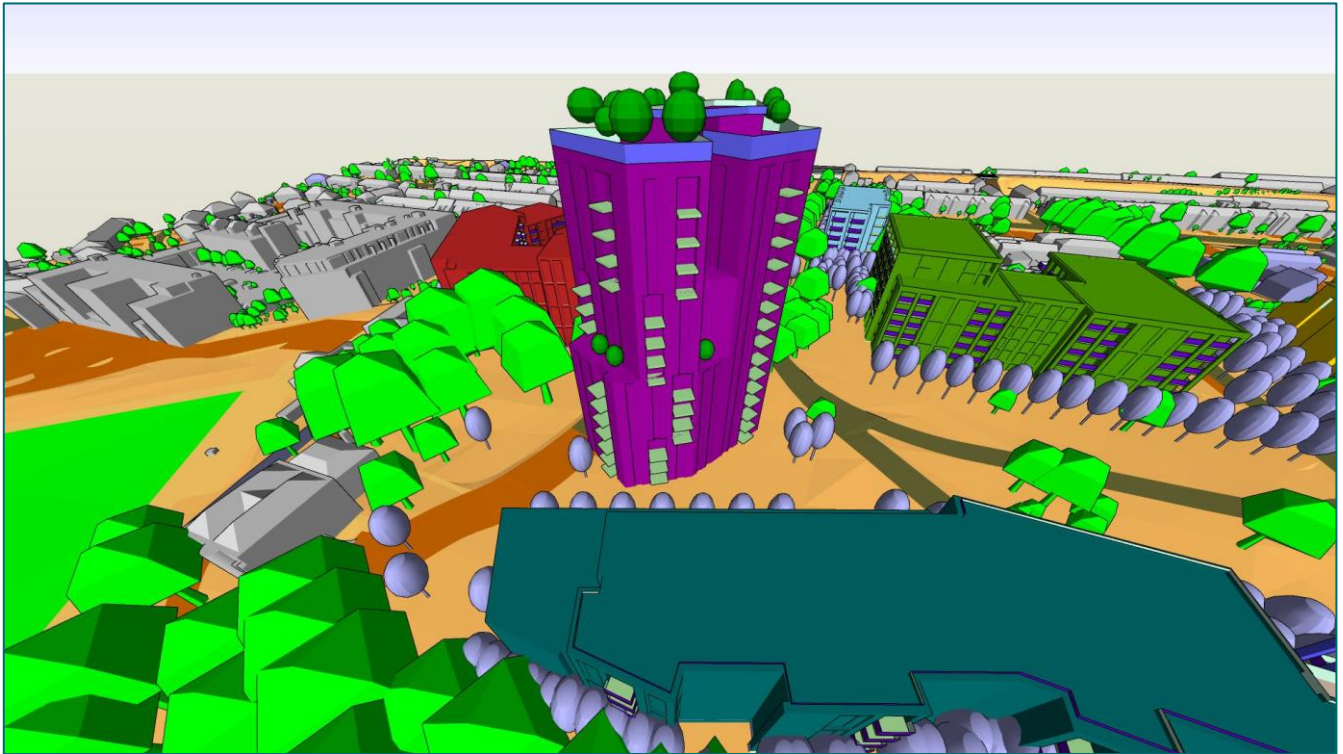


Figure 34: Closer view of ODT D1 tower from east

6.2 Comfort Activities

The following table lists the various activities according to the amenity type will be focused mainly in the simulation.

Amenity Area	Business Walking	Leisurely Walking	Standing	Sitting
Ground level amenities	✓	✓	✓	✓
Roof level amenities	✓	✓	✓	✓
Balconies of all plots			✓	✓
Streets	✓	✓		

7 Results

7.1 Comfort Criteria: All Seasons

7.1.1 Sitting Comfort Criteria

Figures 35 to 42 show the percentage of the year the hourly wind speed exceeds the threshold value for the sitting comfort criteria for all seasons. The threshold value is 4m/s.

7.1.1.1 Overall Site

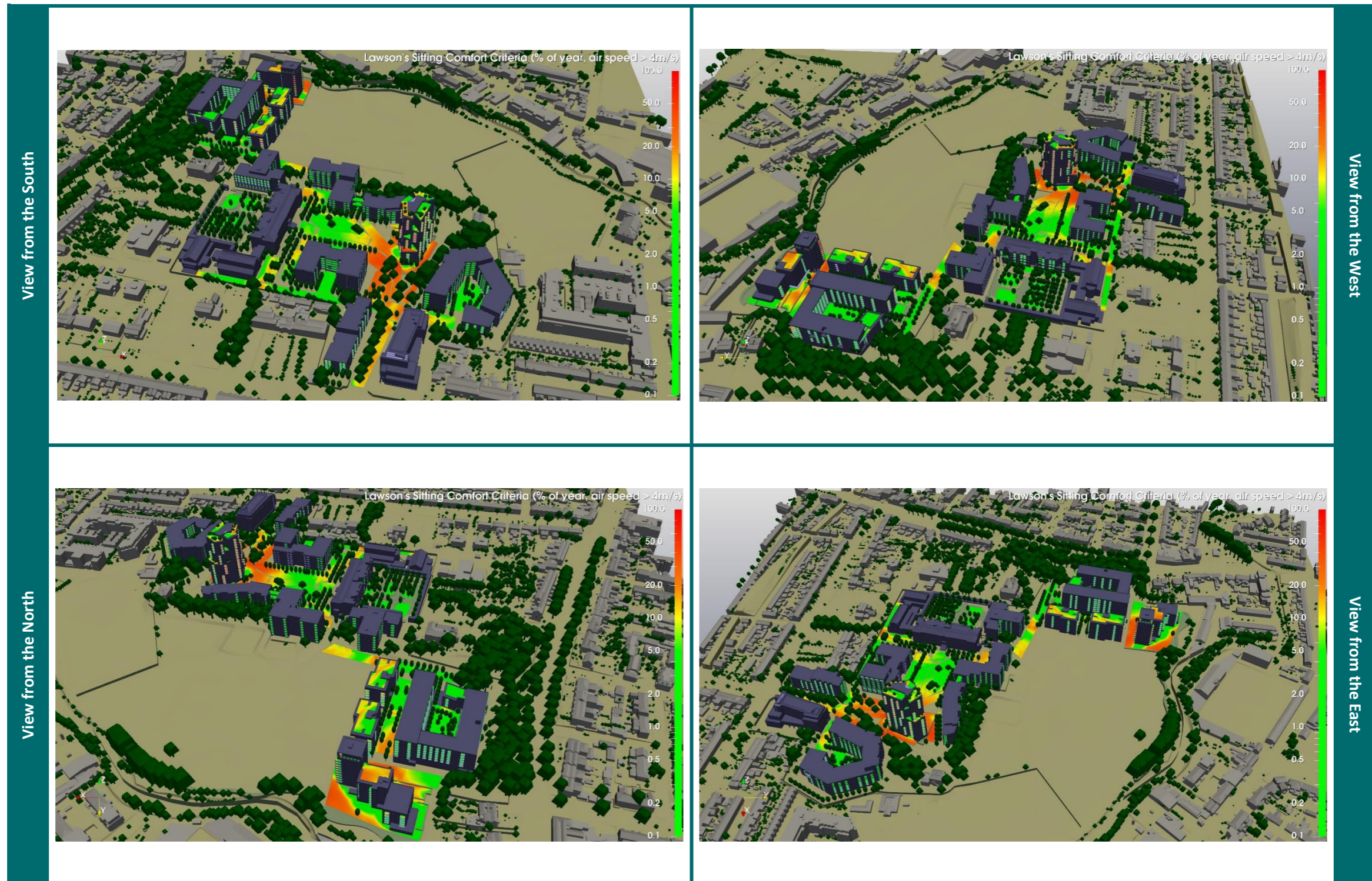


Figure 35: Sitting Comfort Criteria: Overall Site

7.1.1.2 OMP Blocks A1 to A4

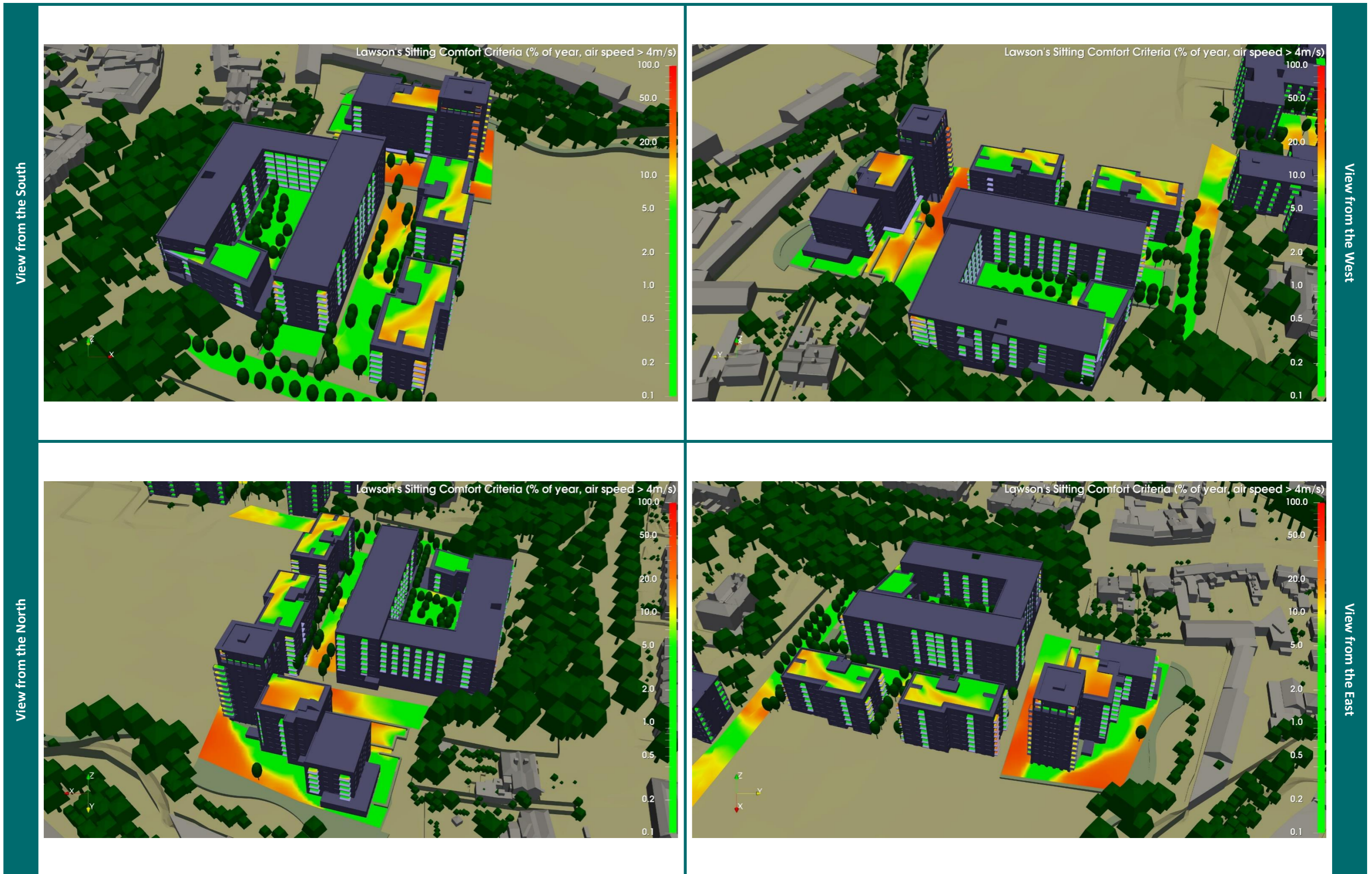


Figure 36: Sitting Comfort Criteria: OMP Blocks A1 to A4

7.1.1.3 HJL Block B1 and MCM Extension

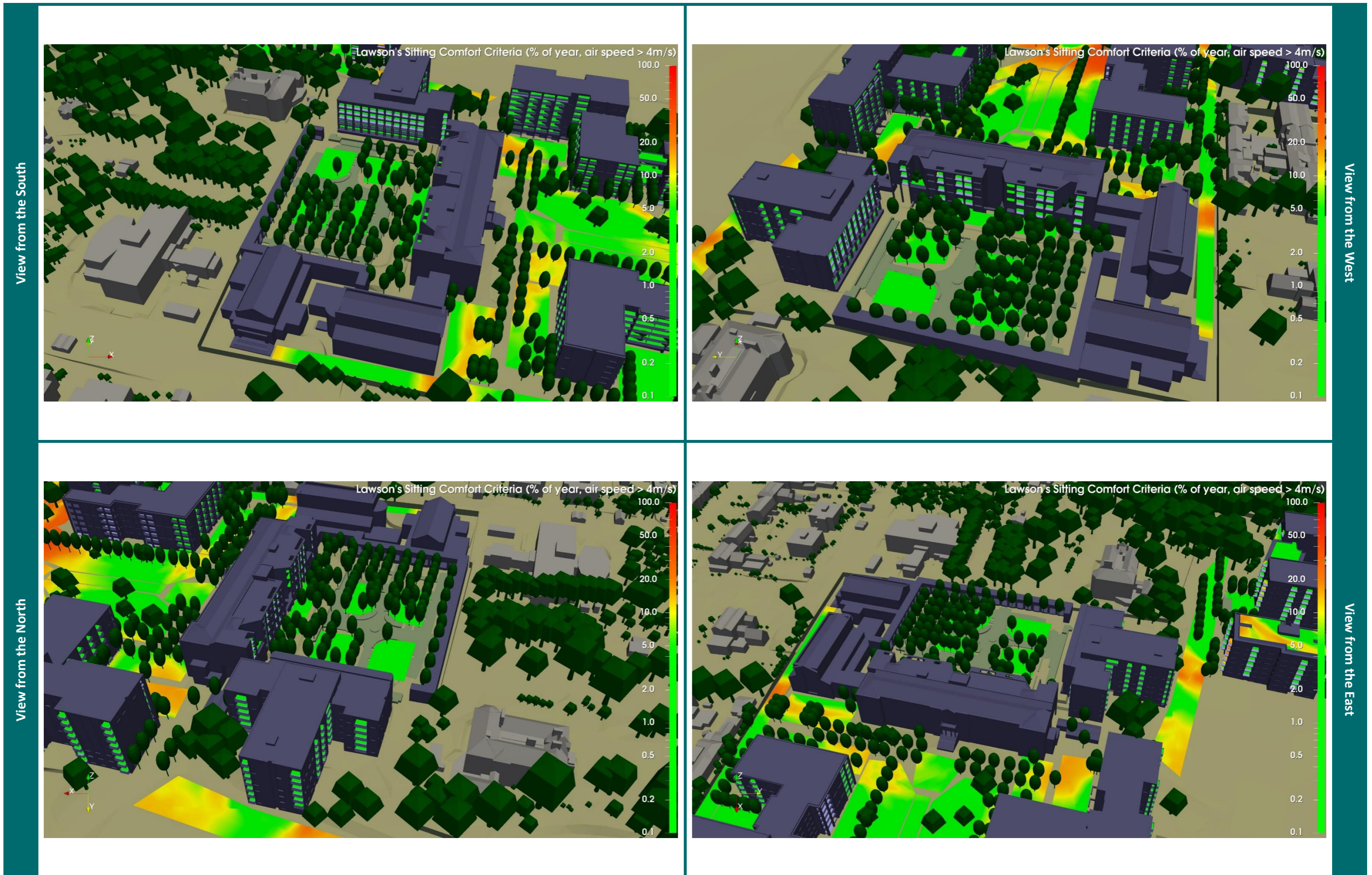


Figure 37: Sitting Comfort Criteria: HJL Block B1 and MCM Extension

7.1.1.4 HJL Block B2 & B3

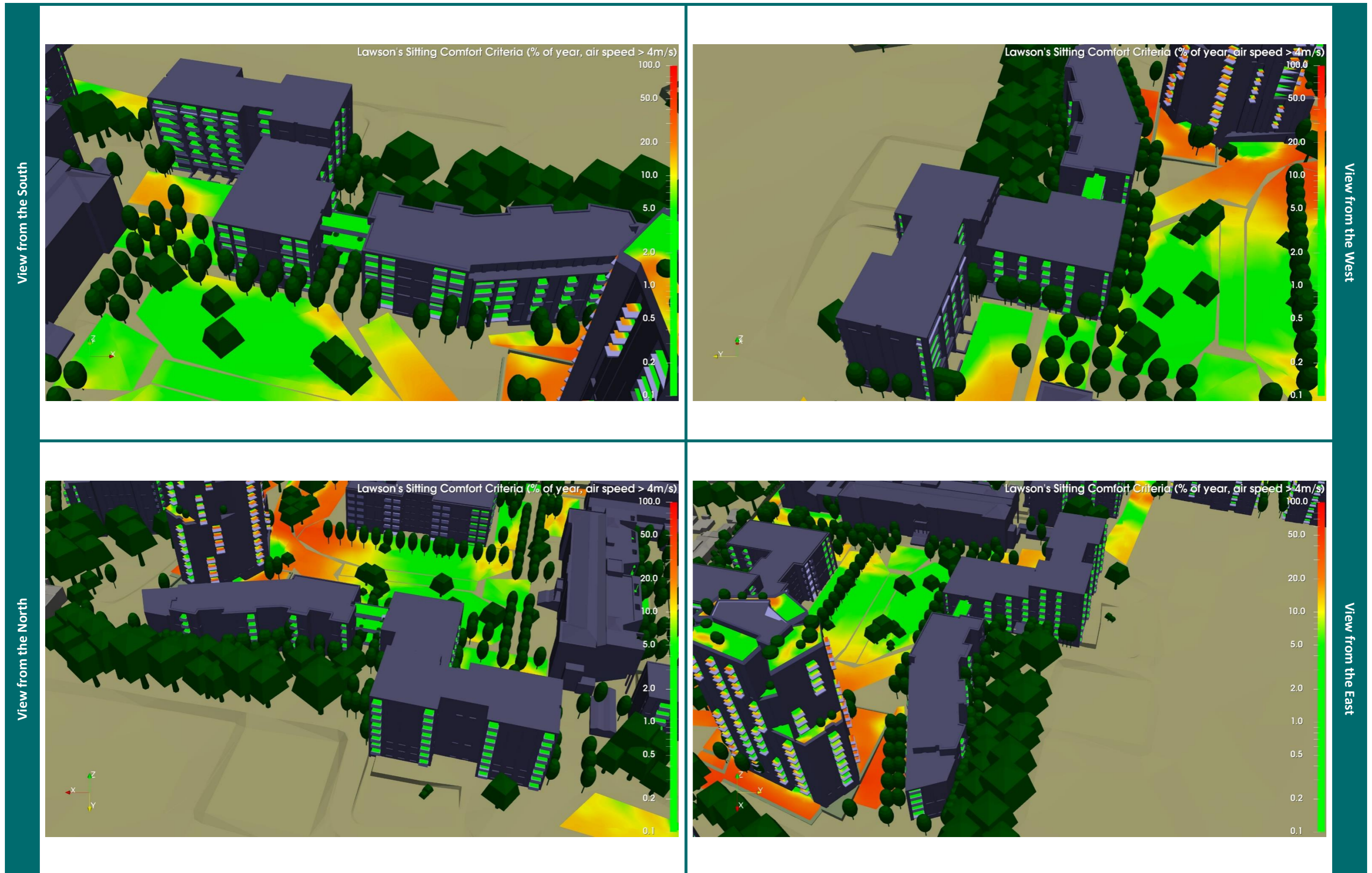


Figure 38: Sitting Comfort Criteria: HJL Blocks B2 and B3

7.1.1.5 HJL Block C1

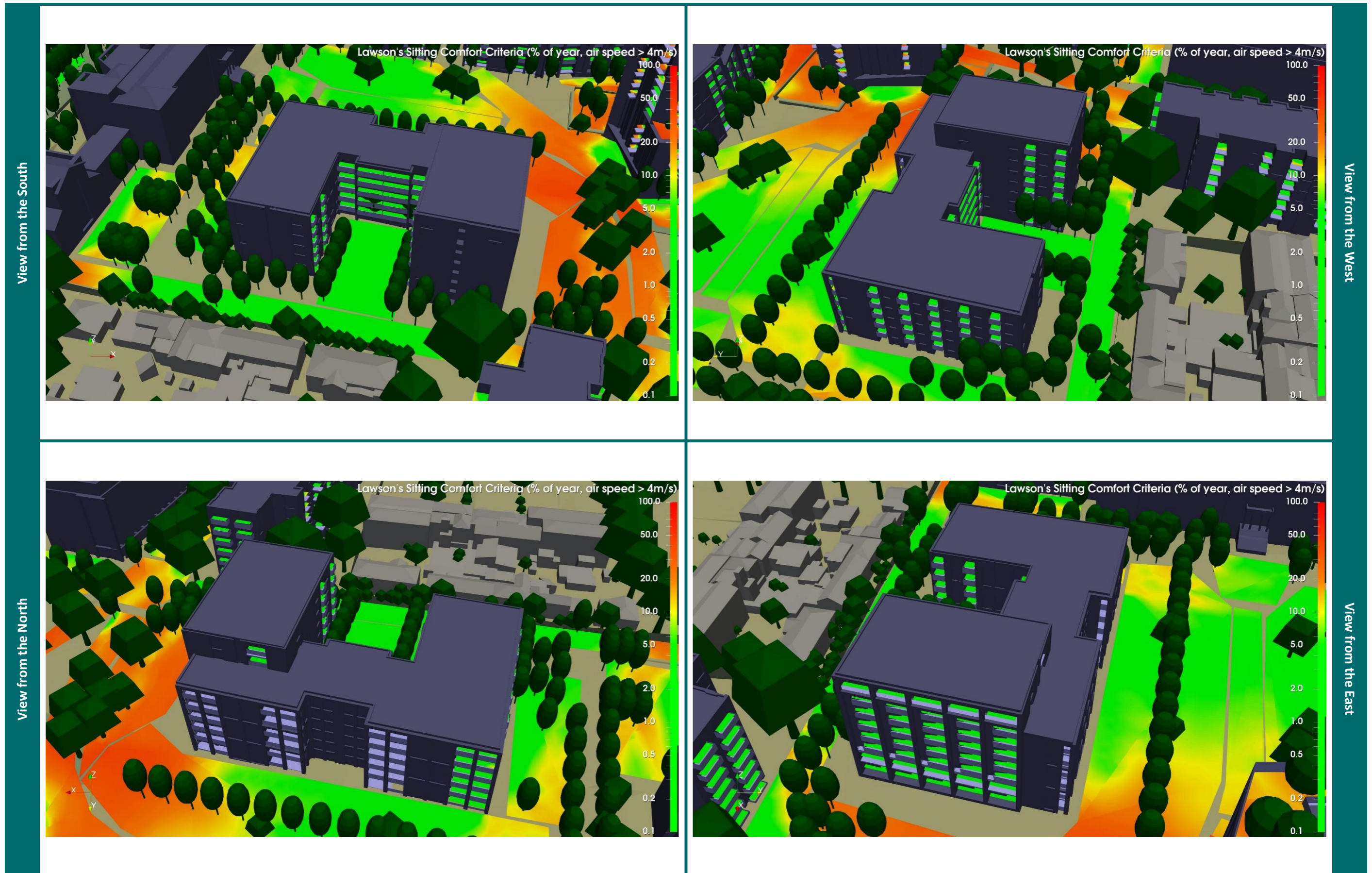


Figure 39: Sitting Comfort Criteria: HJL Block C1

7.1.1.6 HJL Block C2

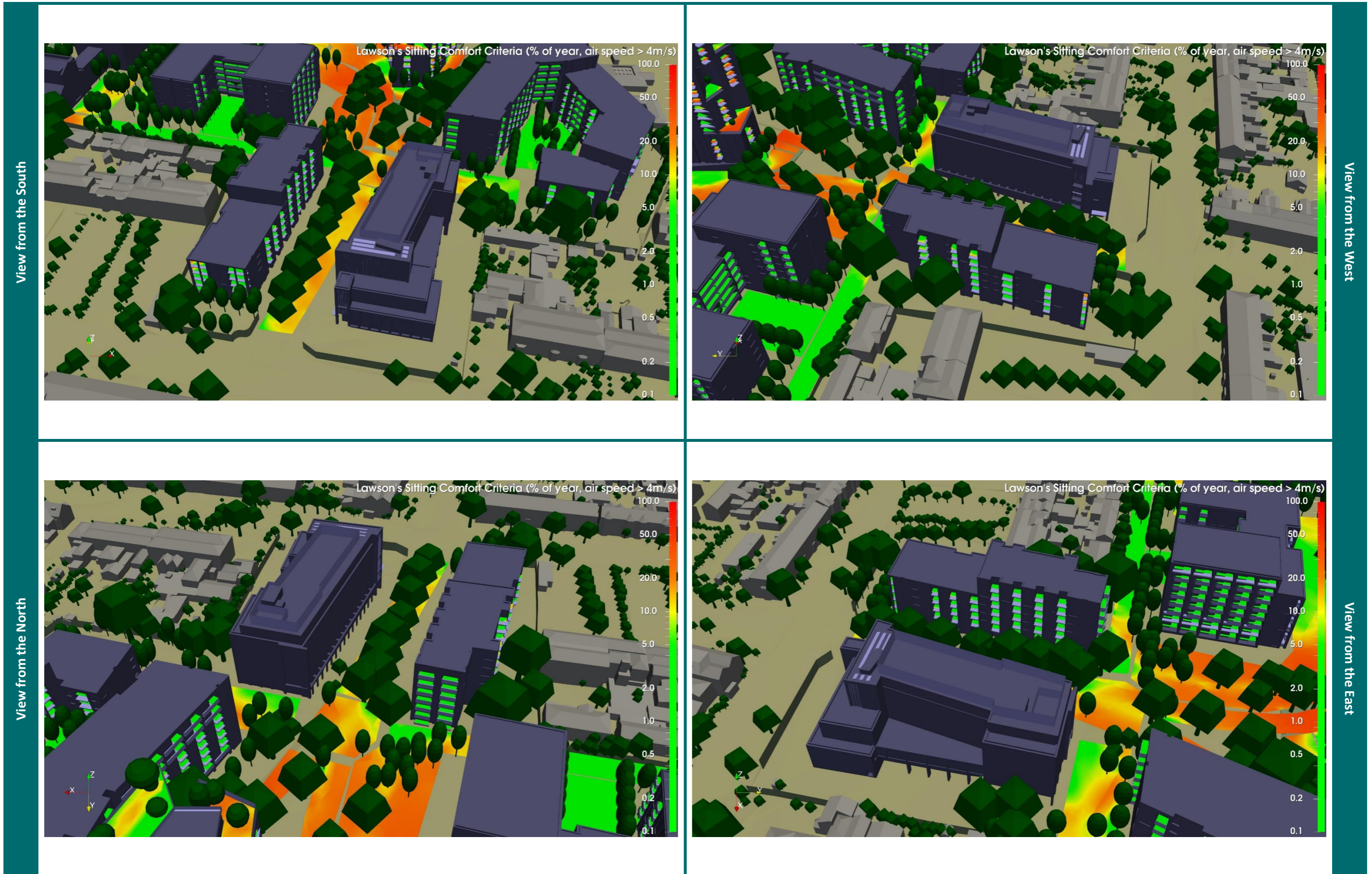


Figure 40: Sitting Comfort Criteria: HJL Block C2

7.1.1.7 ODT Block D1

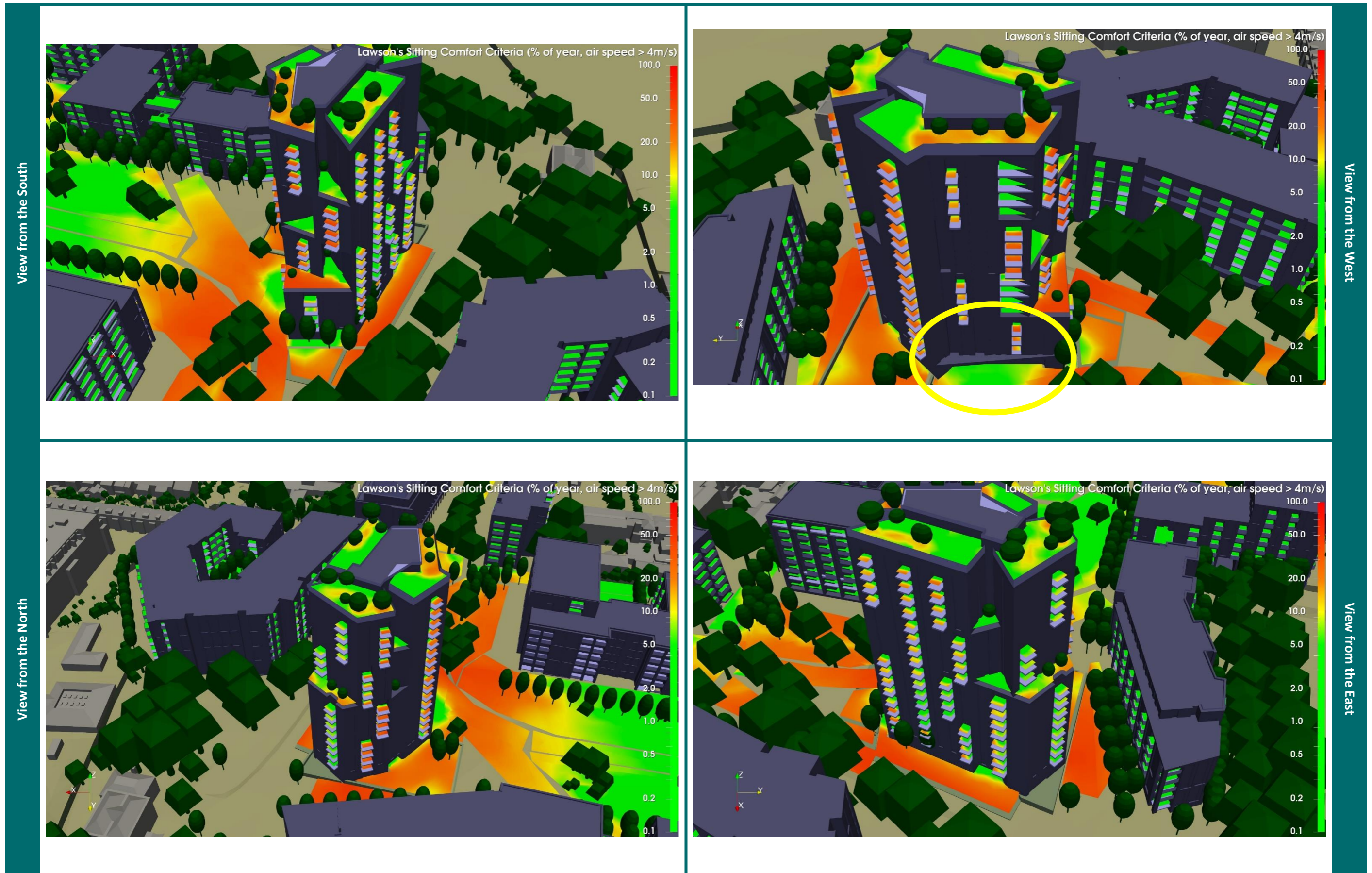


Figure 41: Sitting Comfort Criteria: ODT Block D1

7.1.1.8 HJL Block D2

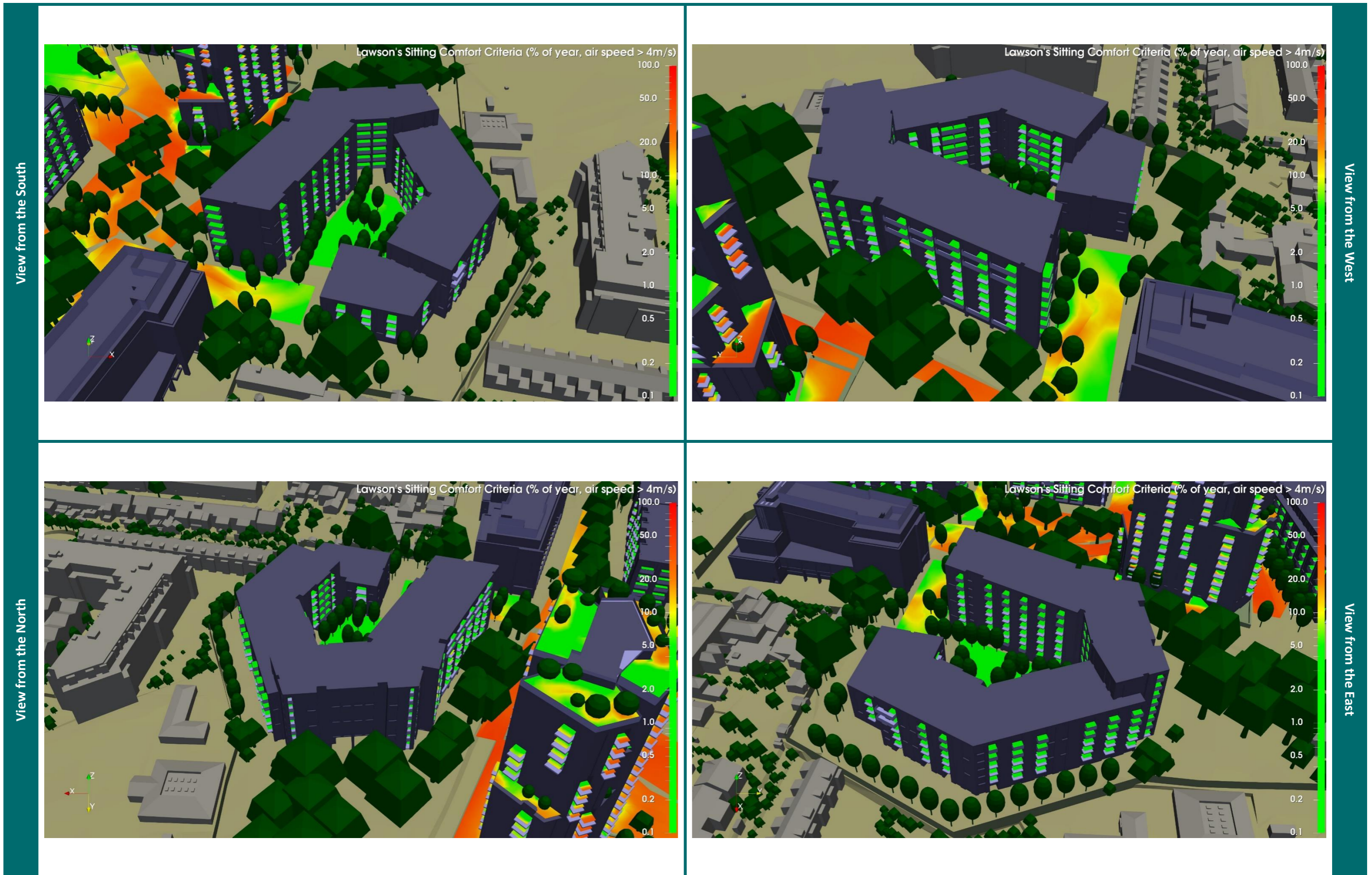


Figure 42: Sitting Comfort Criteria: HJL Block D2

7.1.2 Standing Comfort Criteria

Figures 43 to 50 show the percentage of the year the hourly wind speed exceeds the threshold value for the Standing comfort criteria for all seasons. The threshold value is 4m/s.

7.1.2.1 Overall Site

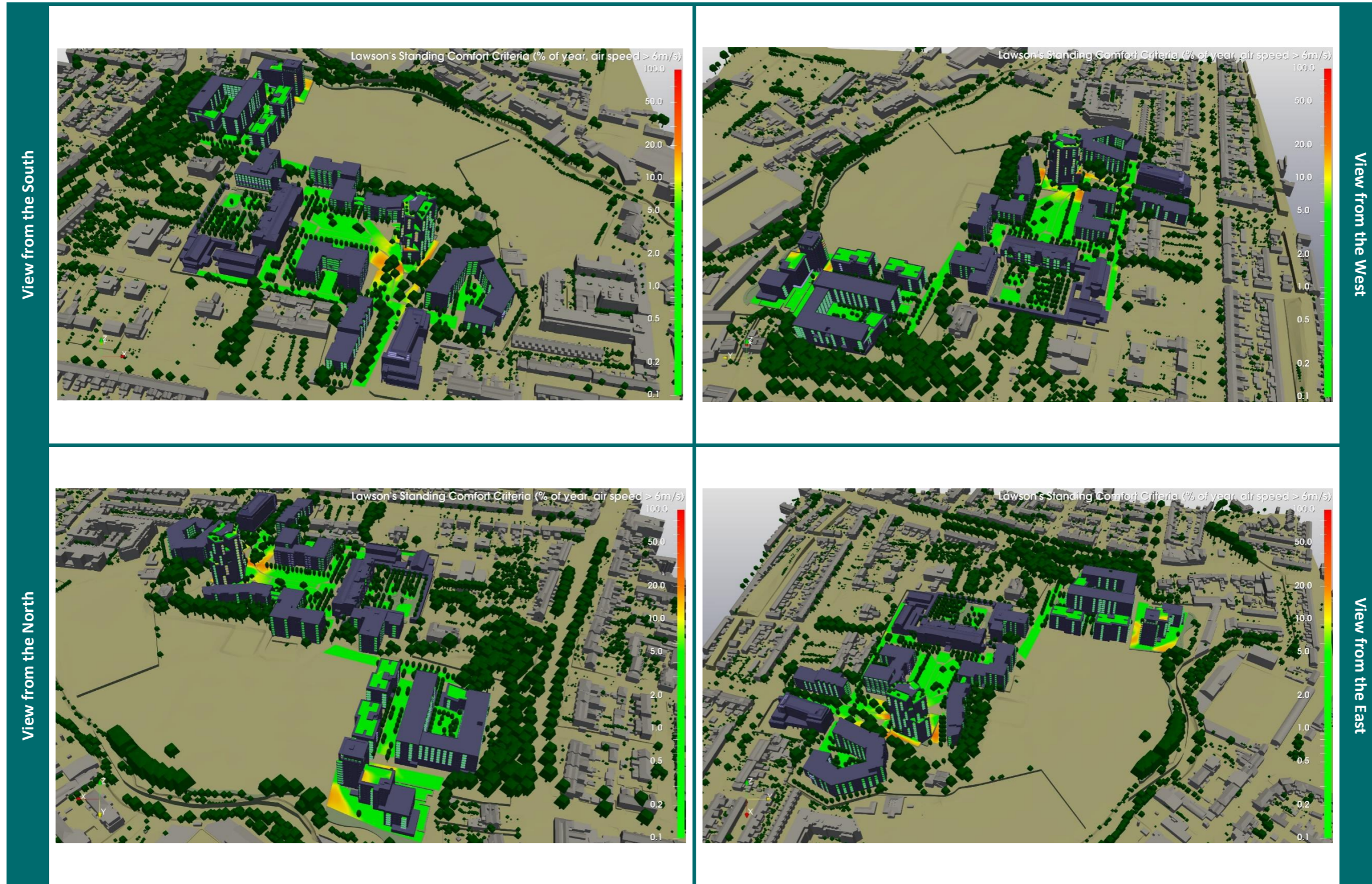


Figure 43: Standing Comfort Criteria: Overall Site

7.1.2.2 OMP Blocks A1 to A4

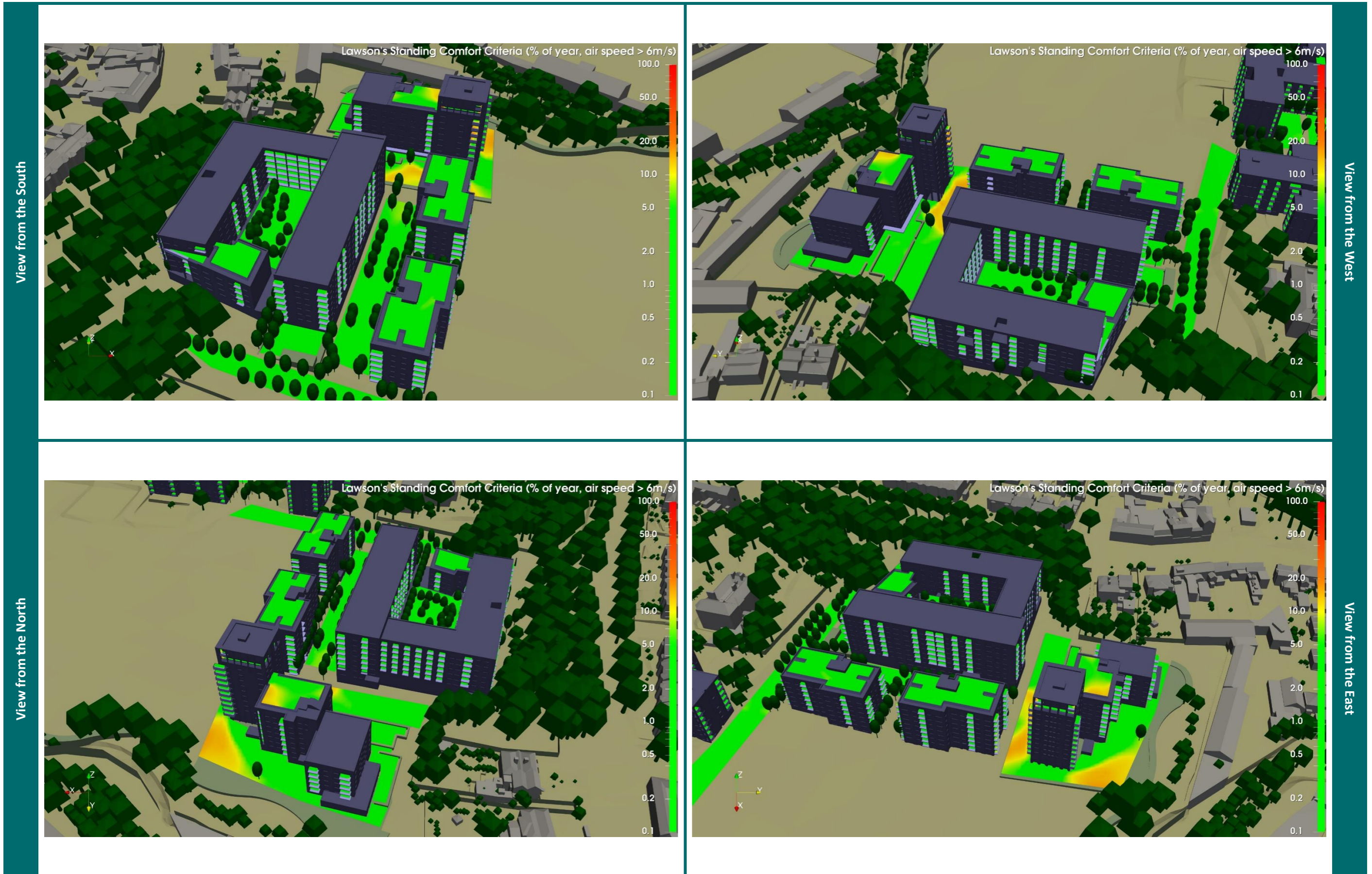


Figure 44: Standing Comfort Criteria: OMP Blocks A1 to A4

7.1.2.3 HJL Block B1 and MCM Extension

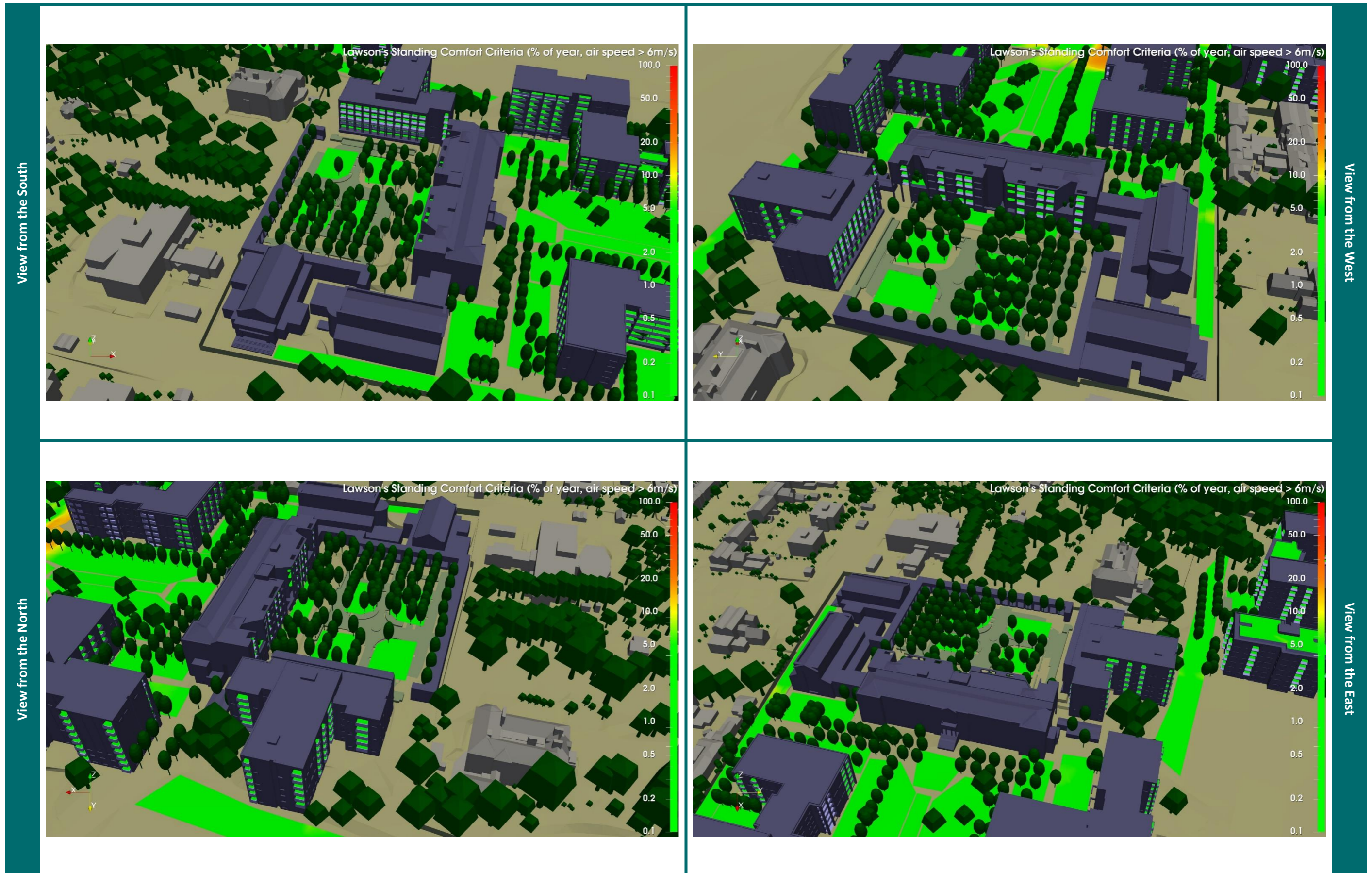


Figure 45: Standing Comfort Criteria: HJL Block B1 and MCM Extension

7.1.2.4 HJL Block B2 & B3

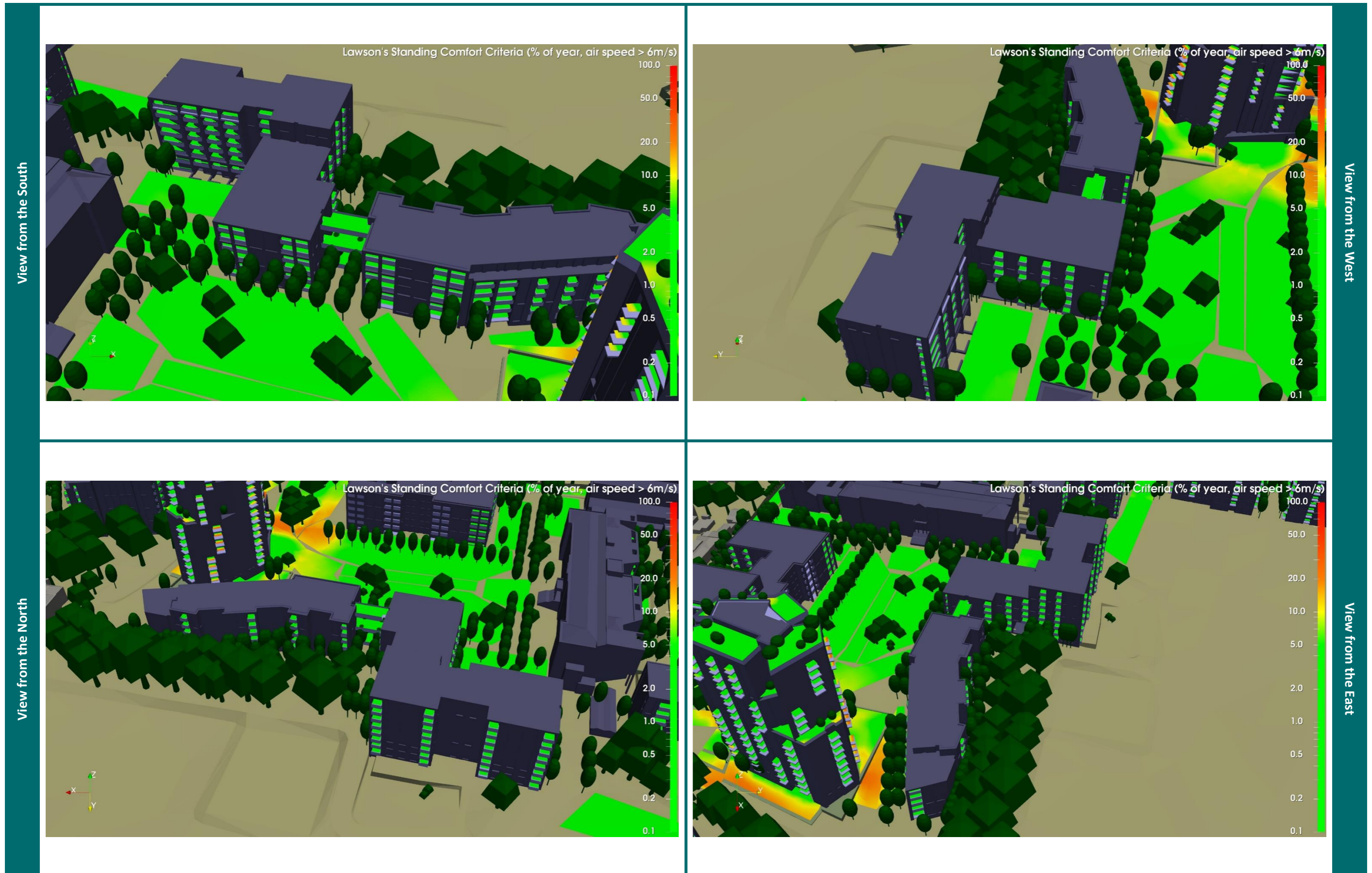


Figure 46: Standing Comfort Criteria: HJL Blocks B2 and B3

7.1.2.5 HJL Block C1

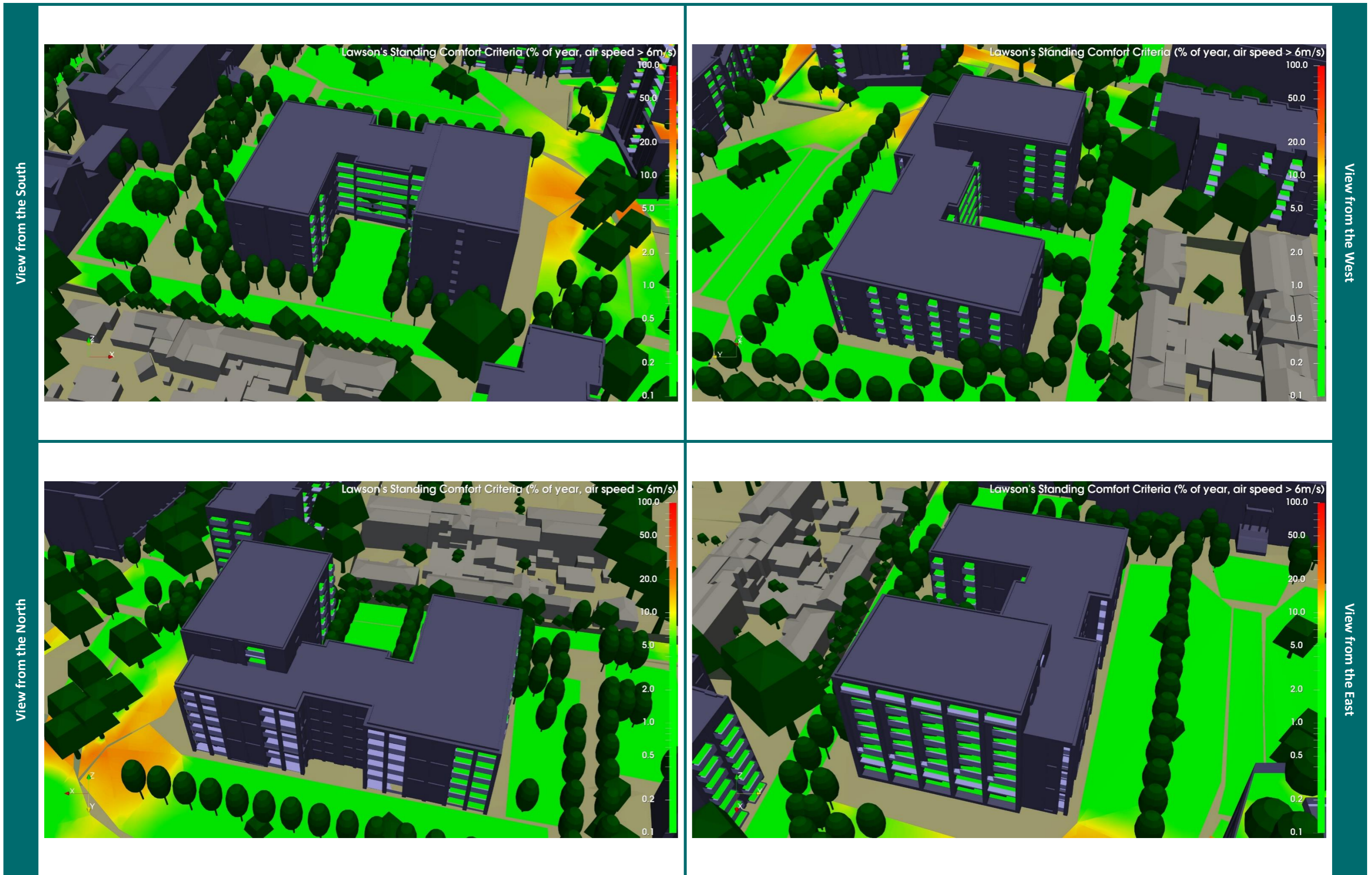


Figure 47: Standing Comfort Criteria: HJL Block C1

7.1.2.6 HJL Block C2

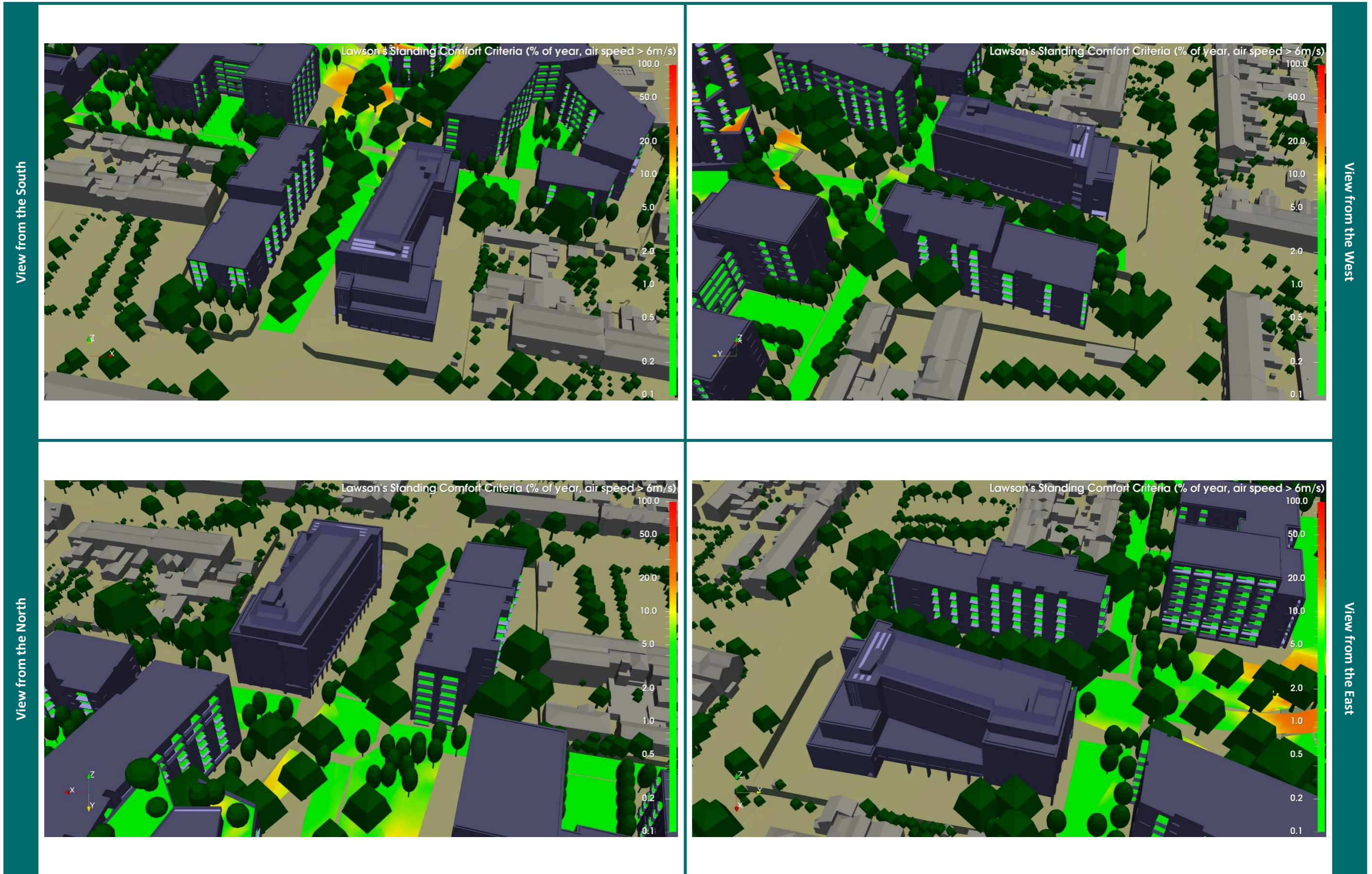


Figure 48: Standing Comfort Criteria: HJL Block C2

7.1.2.7 ODT Block D1

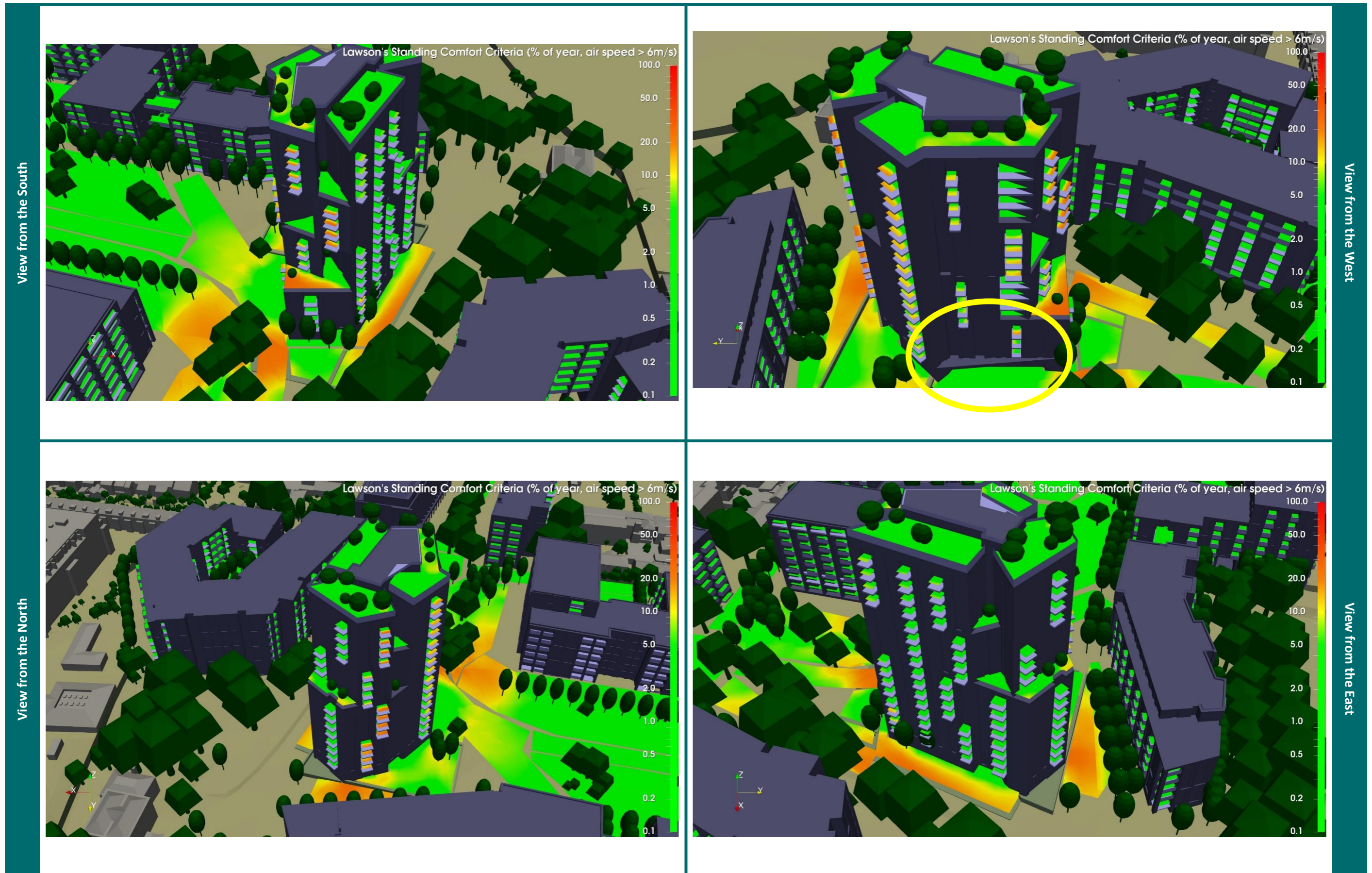


Figure 49: Standing Comfort Criteria: ODT Block D1

7.1.2.8 HJL Block D2

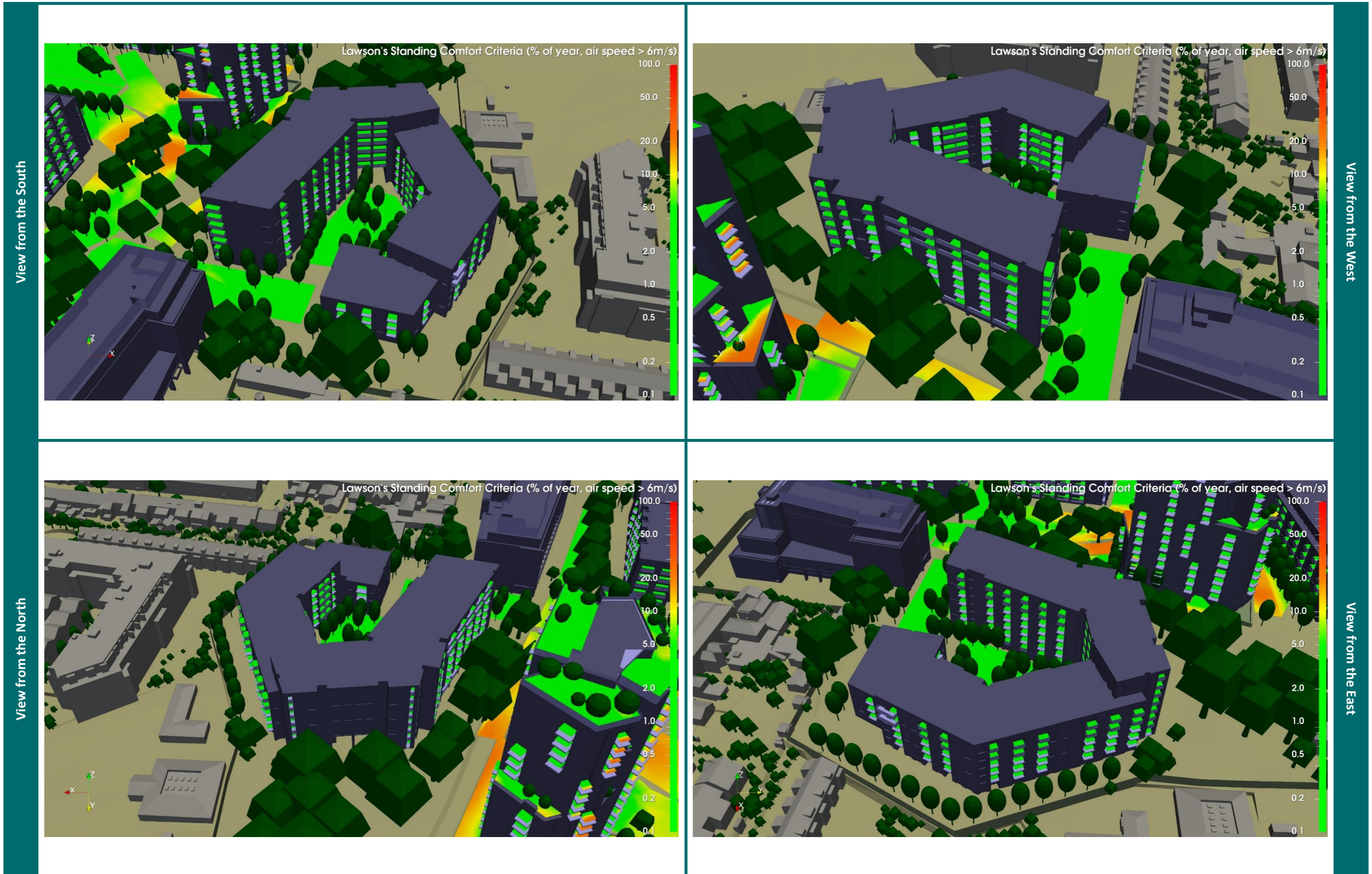


Figure 50: Standing Comfort Criteria: HJL Block D2

7.1.3 Leisure Walking Comfort Criteria

Figures 51 to 58 show the percentage of the year the hourly wind speed exceeds the threshold value for the Leisure Walking comfort criteria for all seasons. The threshold value is 4m/s.

7.1.3.1 Overall Site

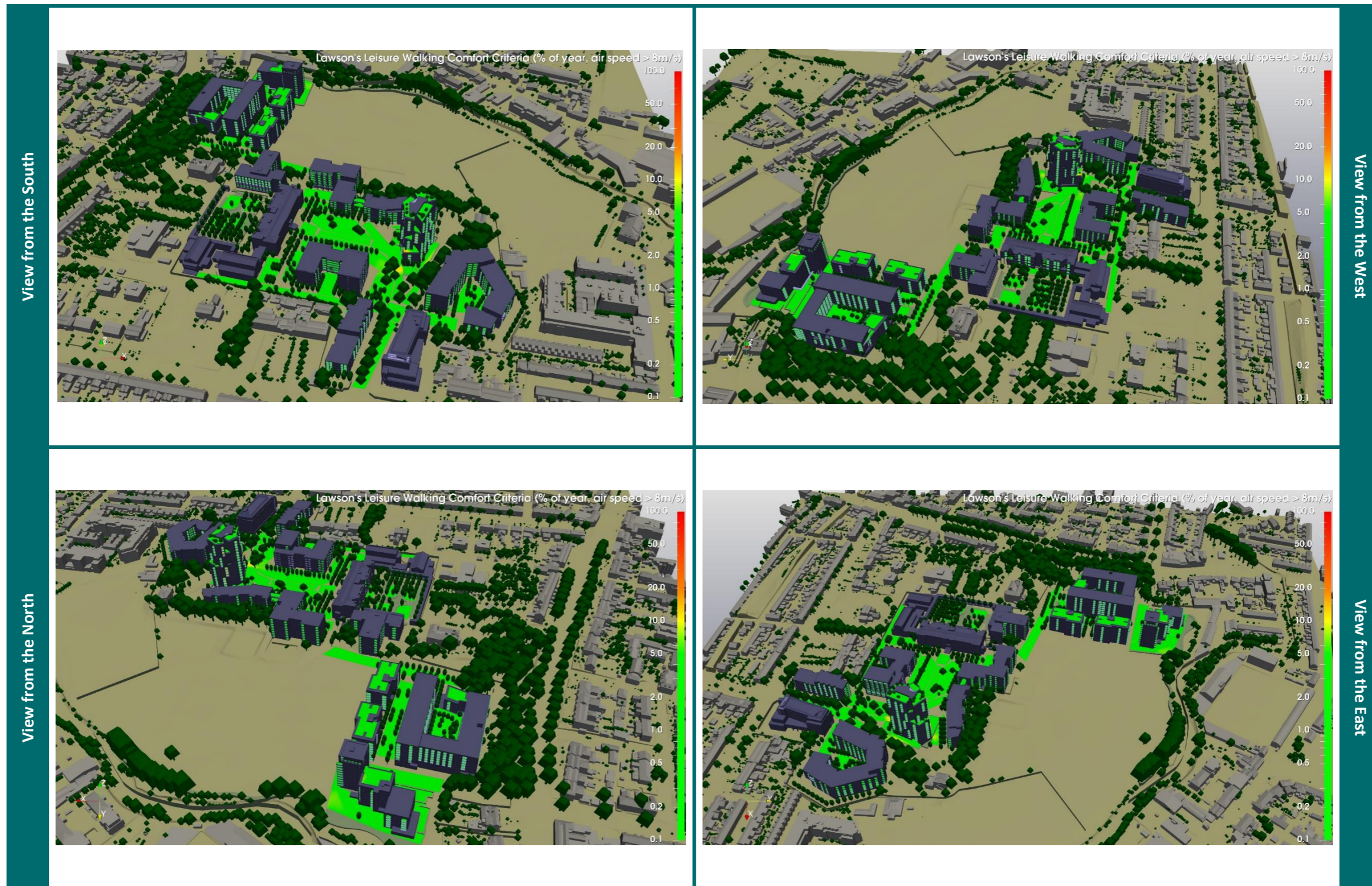


Figure 51: Leisure Walking Comfort Criteria: Overall Site

7.1.3.2 OMP Blocks A1 to A4

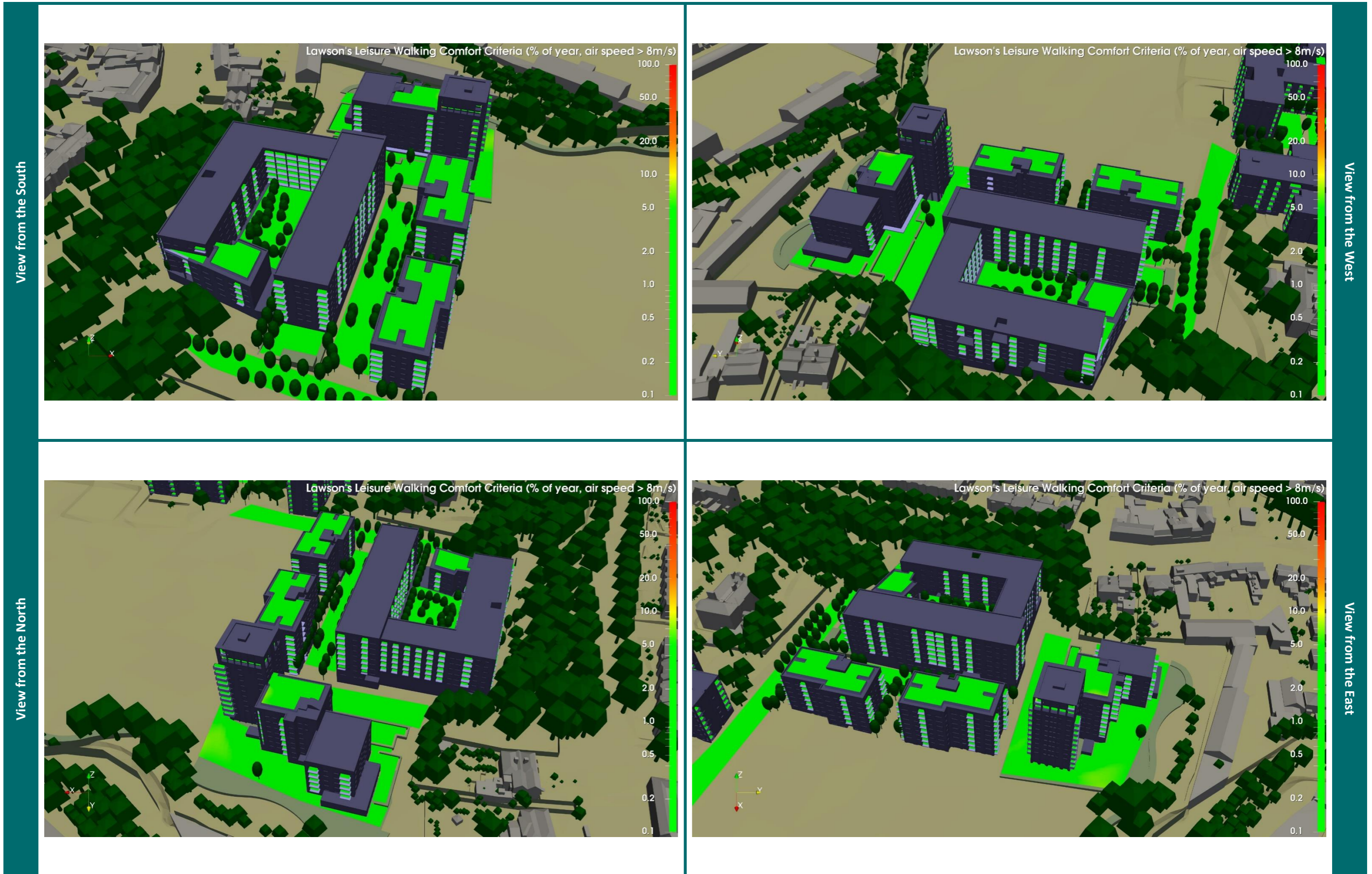


Figure 52: Leisure Walking Comfort Criteria: OMP Blocks A1 to A4

7.1.3.3 HJL Block B1 and MCM Extension

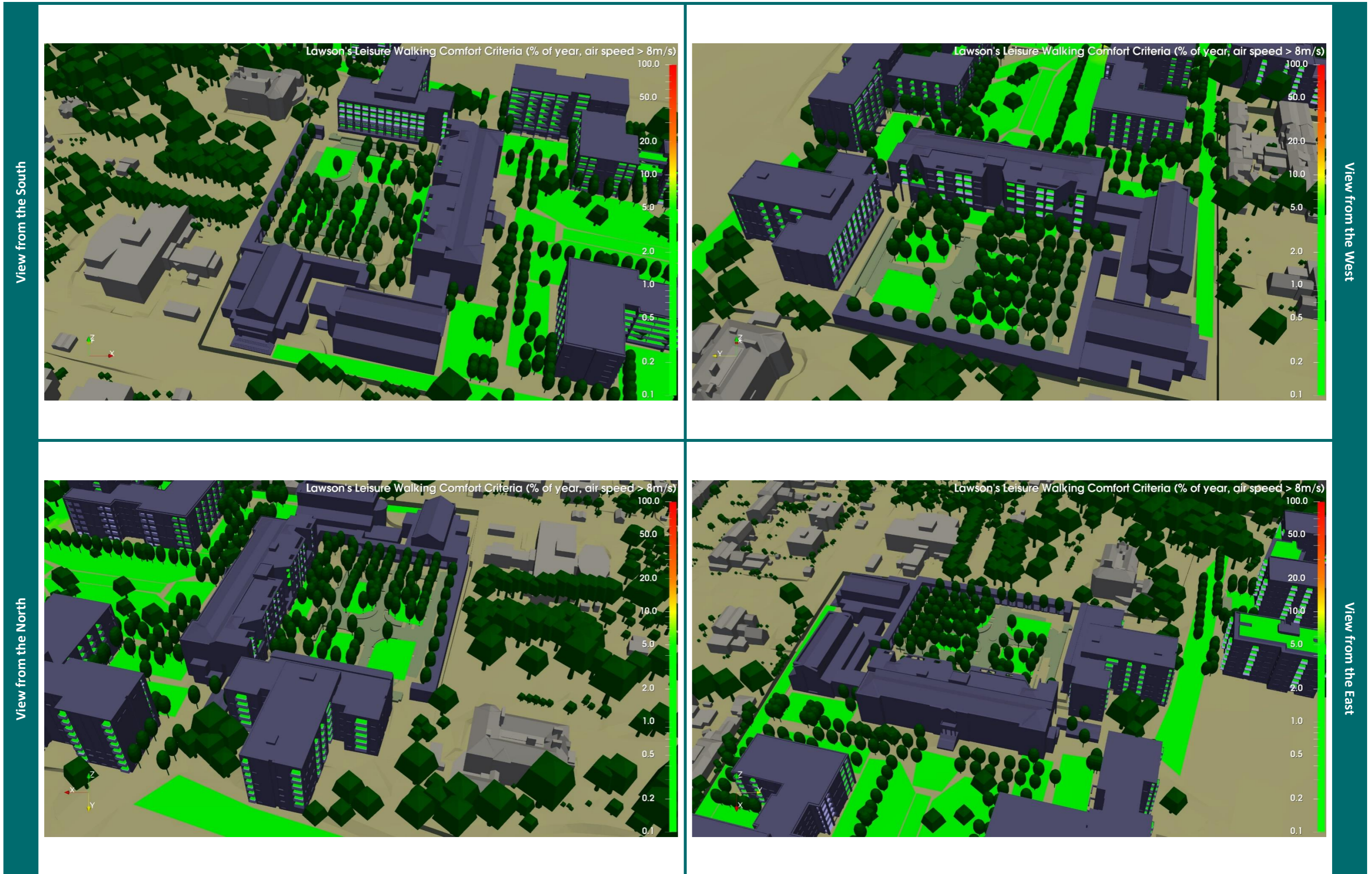


Figure 53: Leisure Walking Comfort Criteria: HJL Block B1 and MCM Extension

7.1.3.4 HJL Block B2 & B3

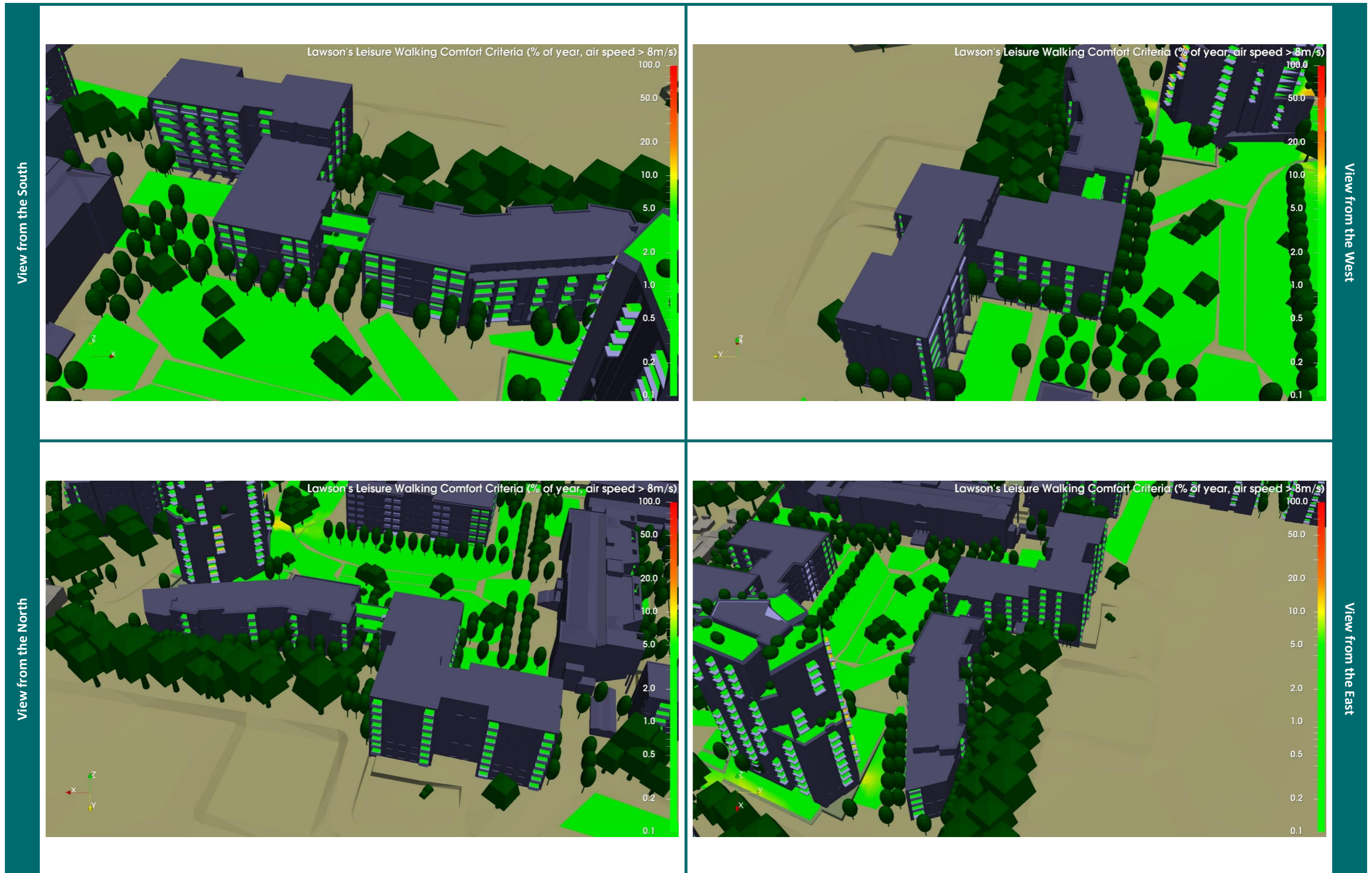


Figure 54: Leisure Walking Comfort Criteria: HJL Blocks B2 and B3

7.1.3.5 HJL Block C1

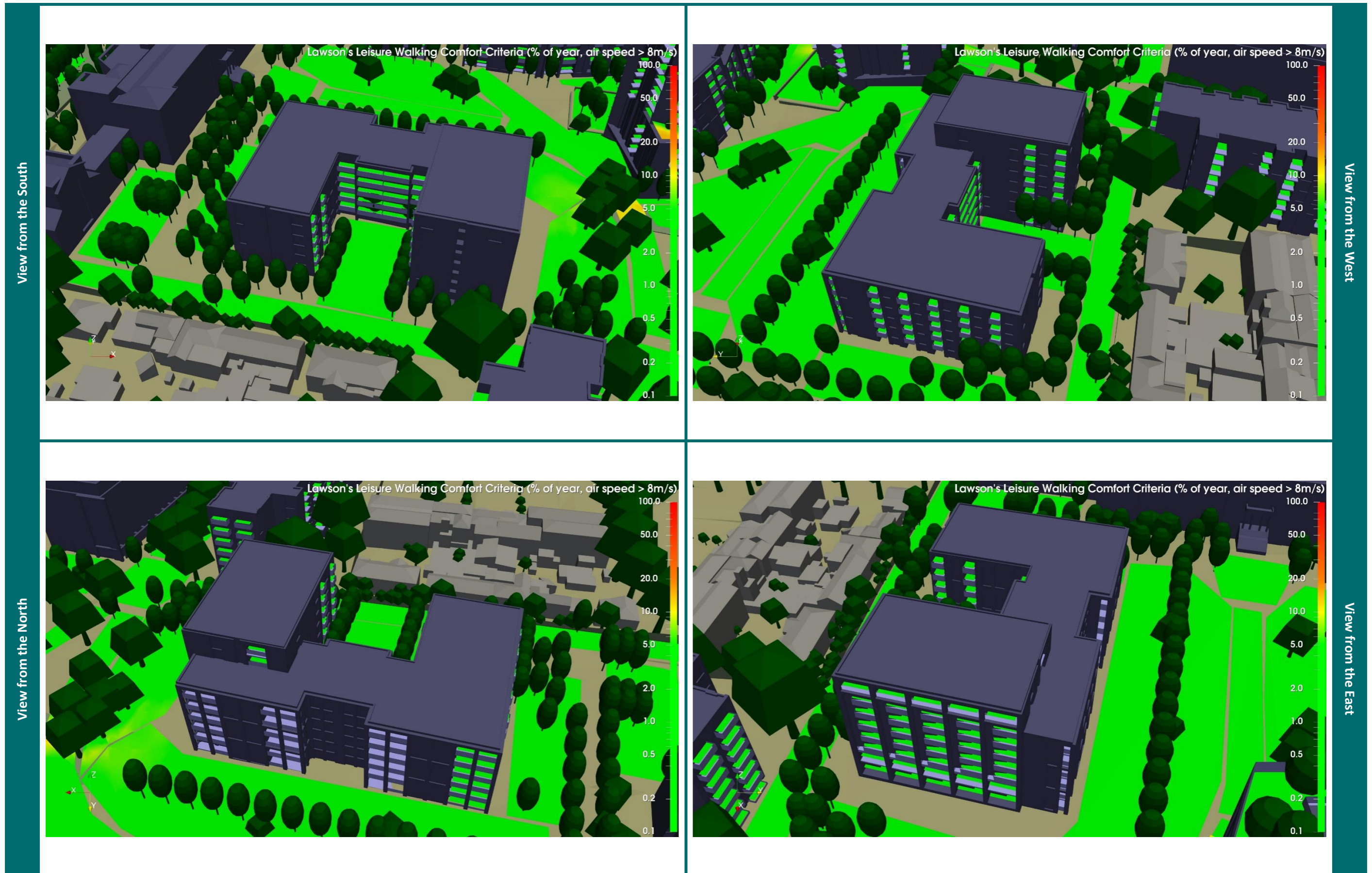


Figure 55: Leisure Walking Comfort Criteria: HJL Block C1

7.1.3.6 HJL Block C2

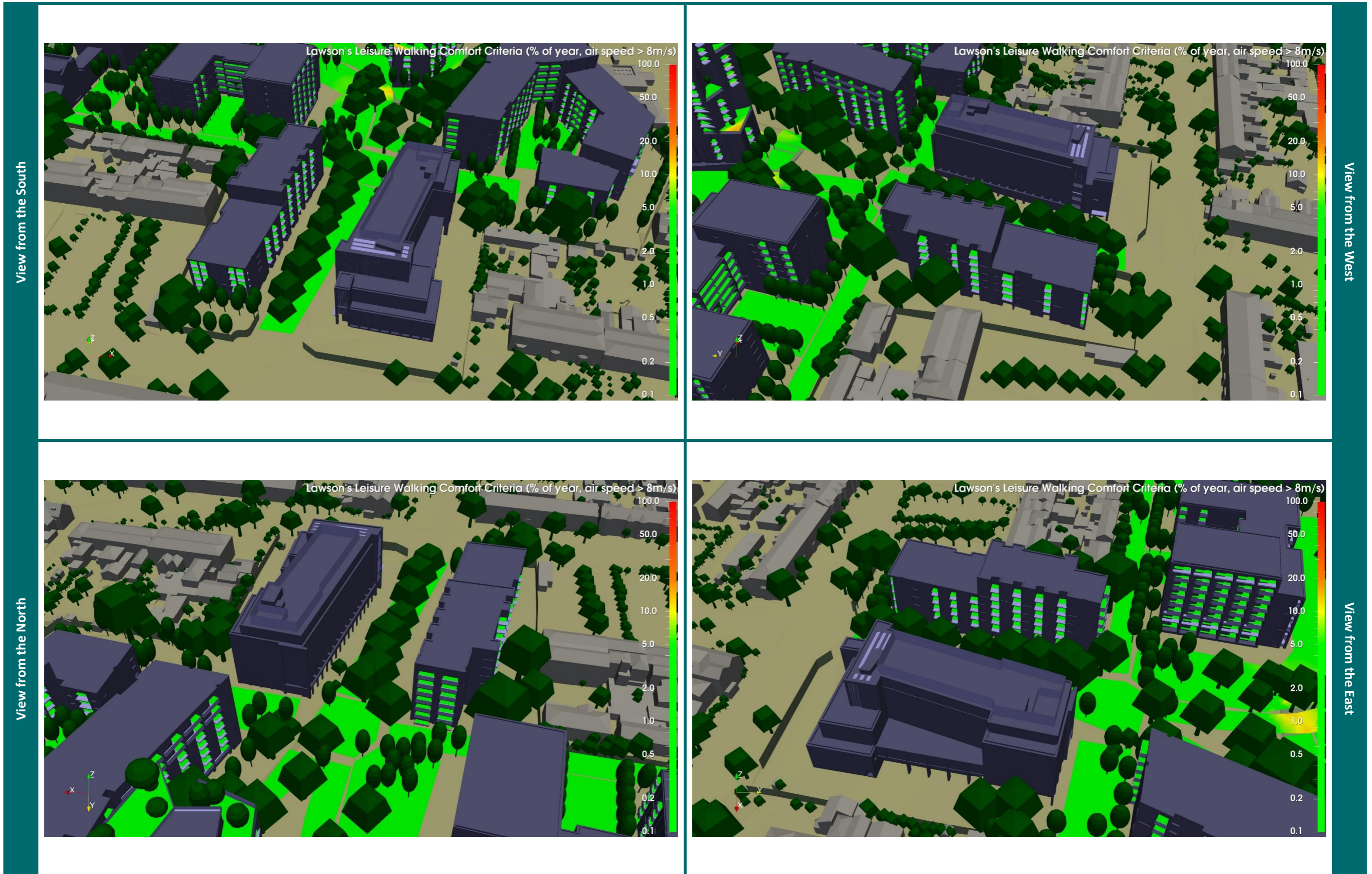


Figure 56: Leisure Walking Comfort Criteria: HJL Block C2

7.1.3.7 ODT Block D1

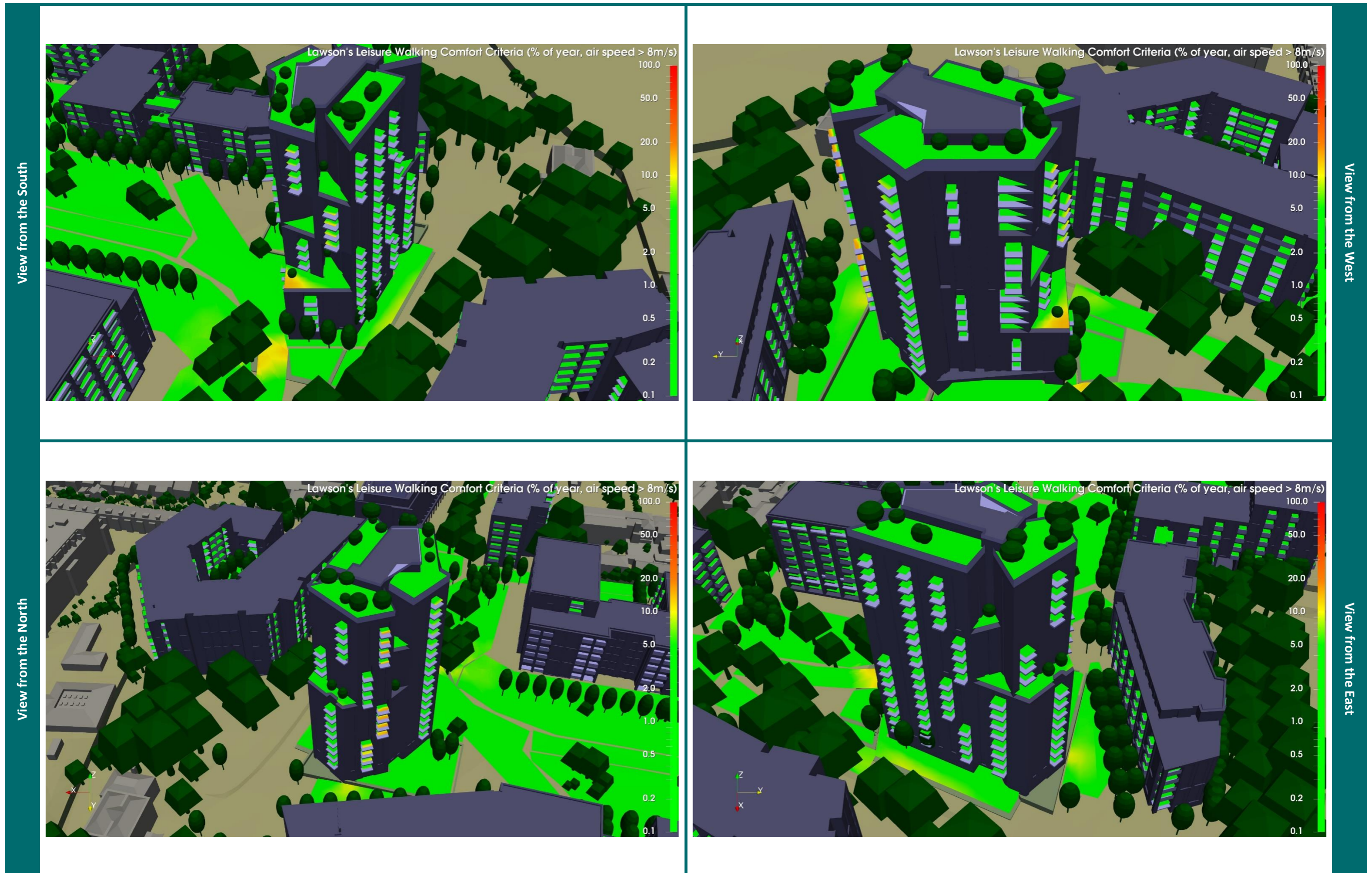


Figure 57: Leisure Walking Comfort Criteria: ODT Block D1

7.1.3.8 HJL Block D2

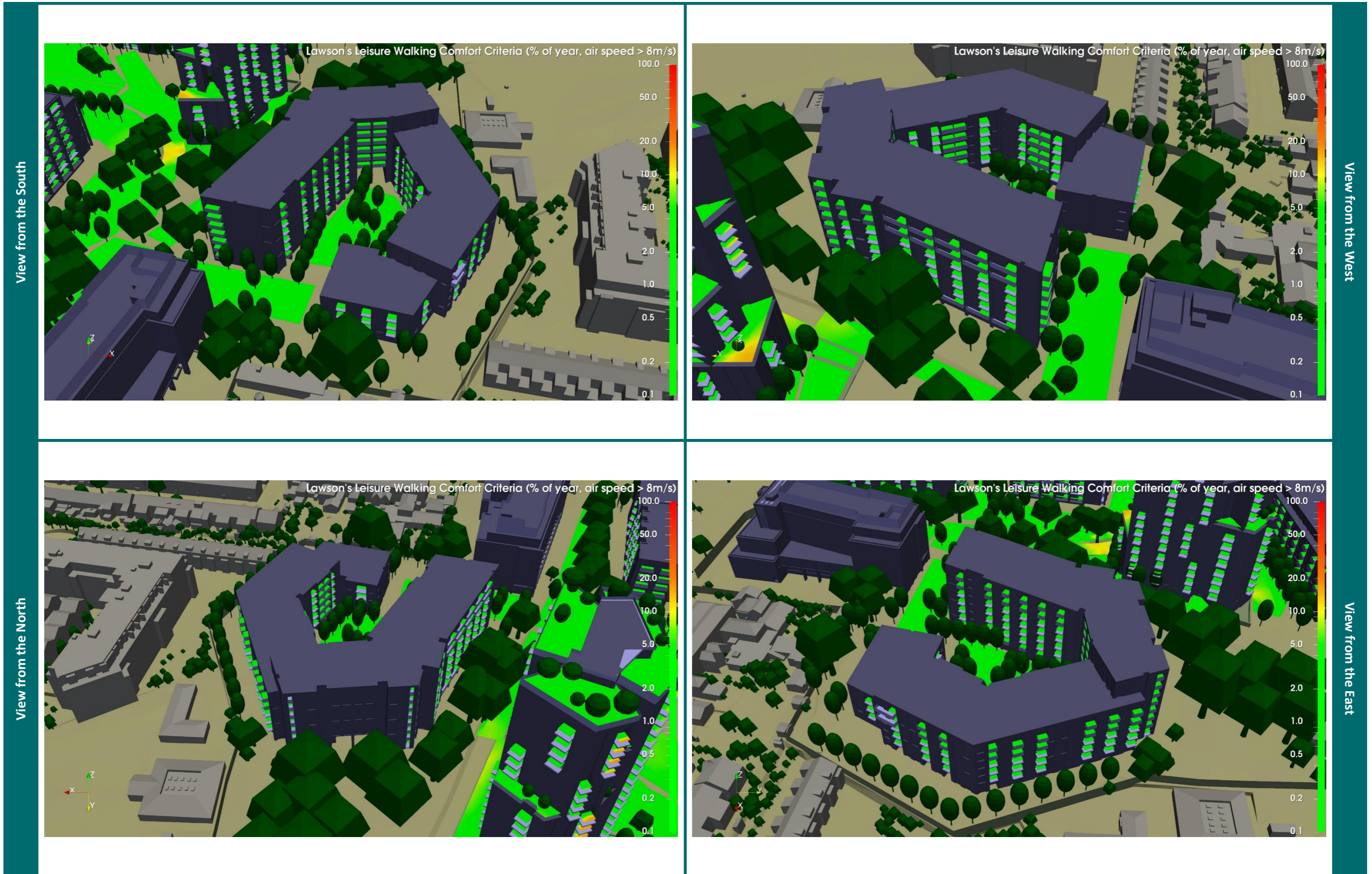


Figure 58: Leisure Walking Comfort Criteria: HJL Block D2

7.1.4 Business Walking Comfort Criteria

Figures 59 to 66 show the percentage of the year the hourly wind speed exceeds the threshold value for the Business Walking comfort criteria for all seasons. The threshold value is 4m/s.

7.1.4.1 Overall Site

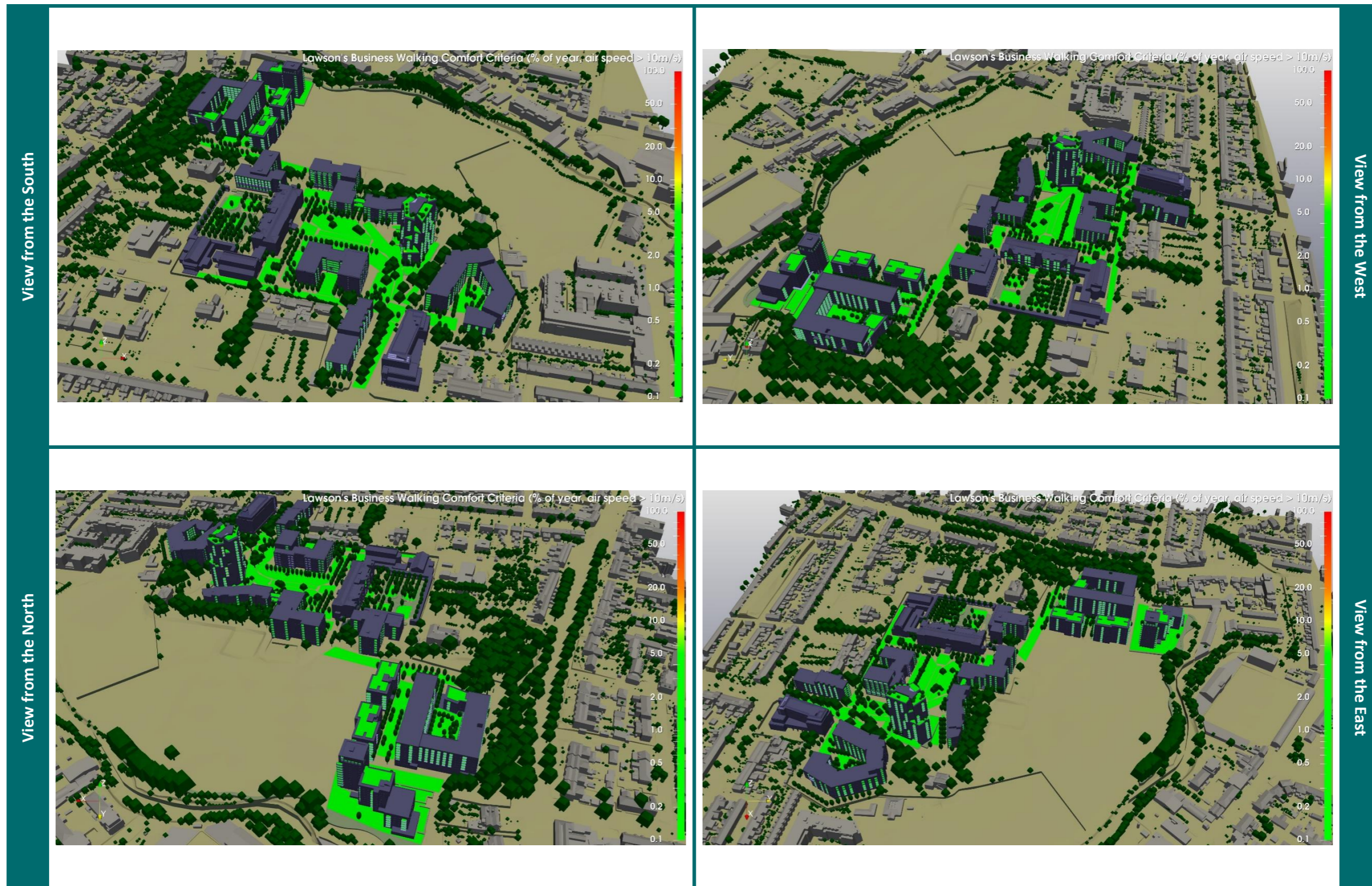


Figure 59: Business Walking Comfort Criteria: Overall Site

7.1.4.2 OMP Blocks A1 to A4

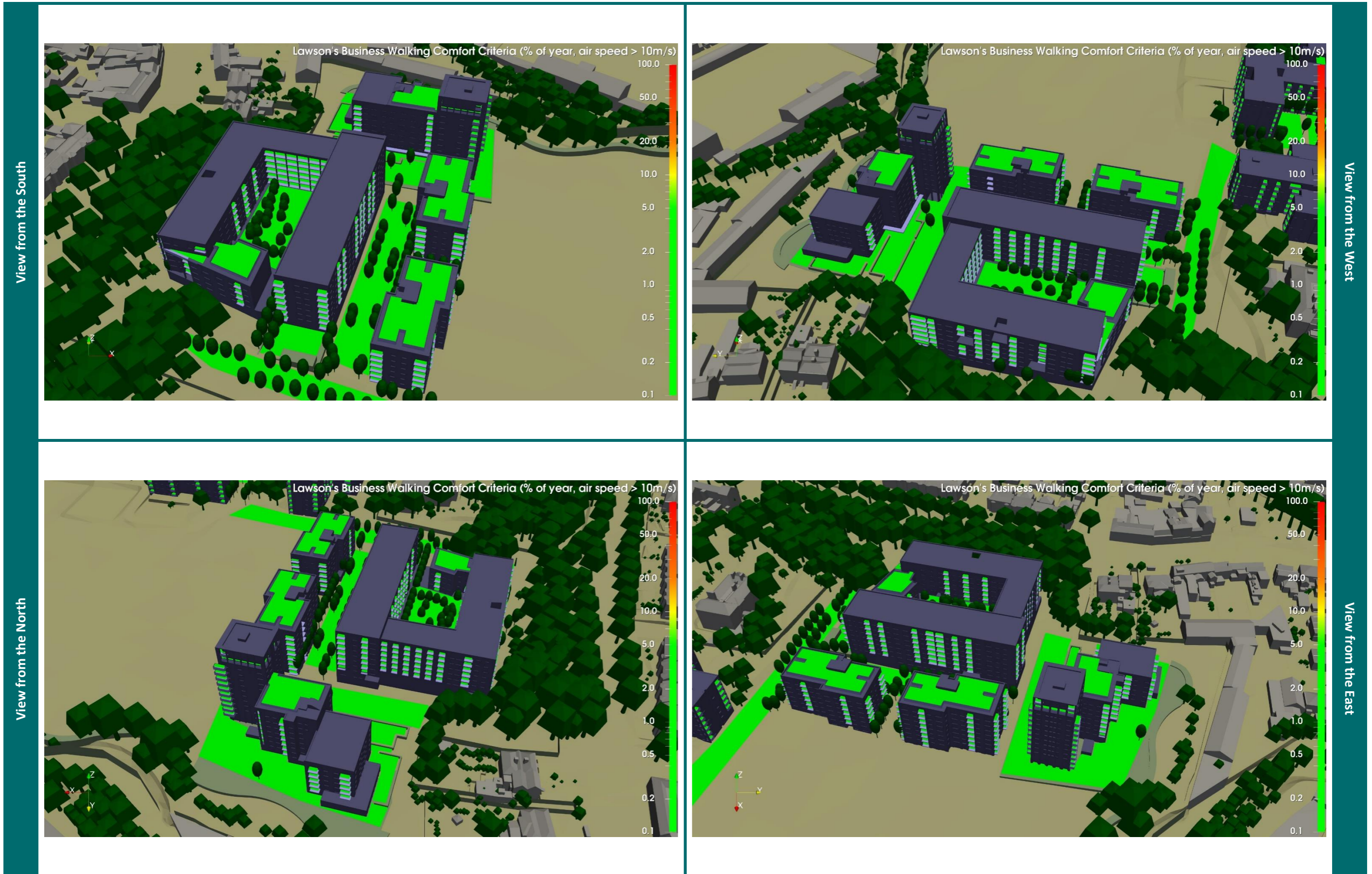


Figure 60: Business Walking Comfort Criteria: OMP Blocks A1 to A4

7.1.4.3 HJL Block B1 and MCM Extension

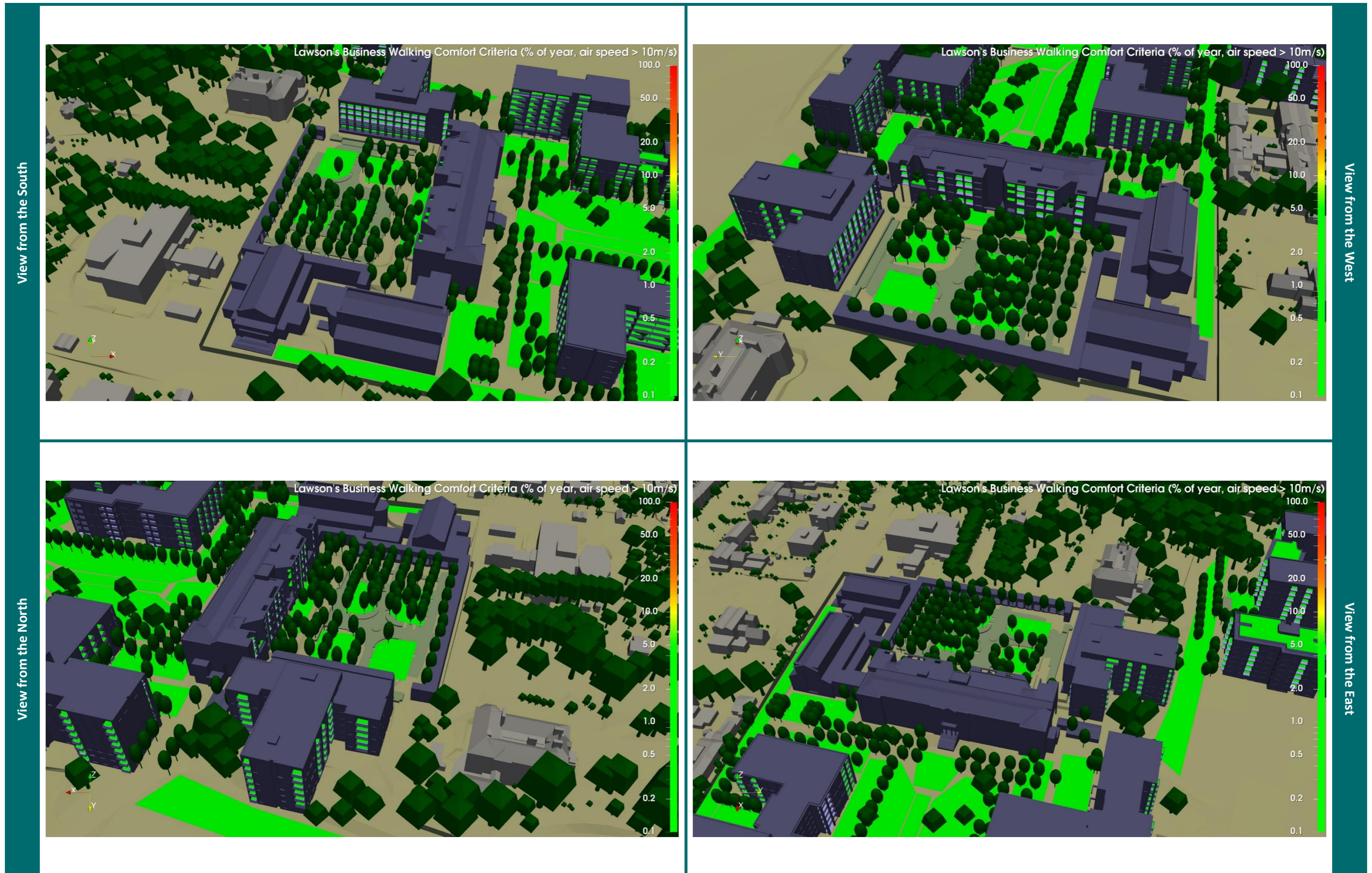


Figure 61: Business Walking Comfort Criteria: HJL Block B1 and MCM Extension

7.1.4.4 HJL Block B2 & B3

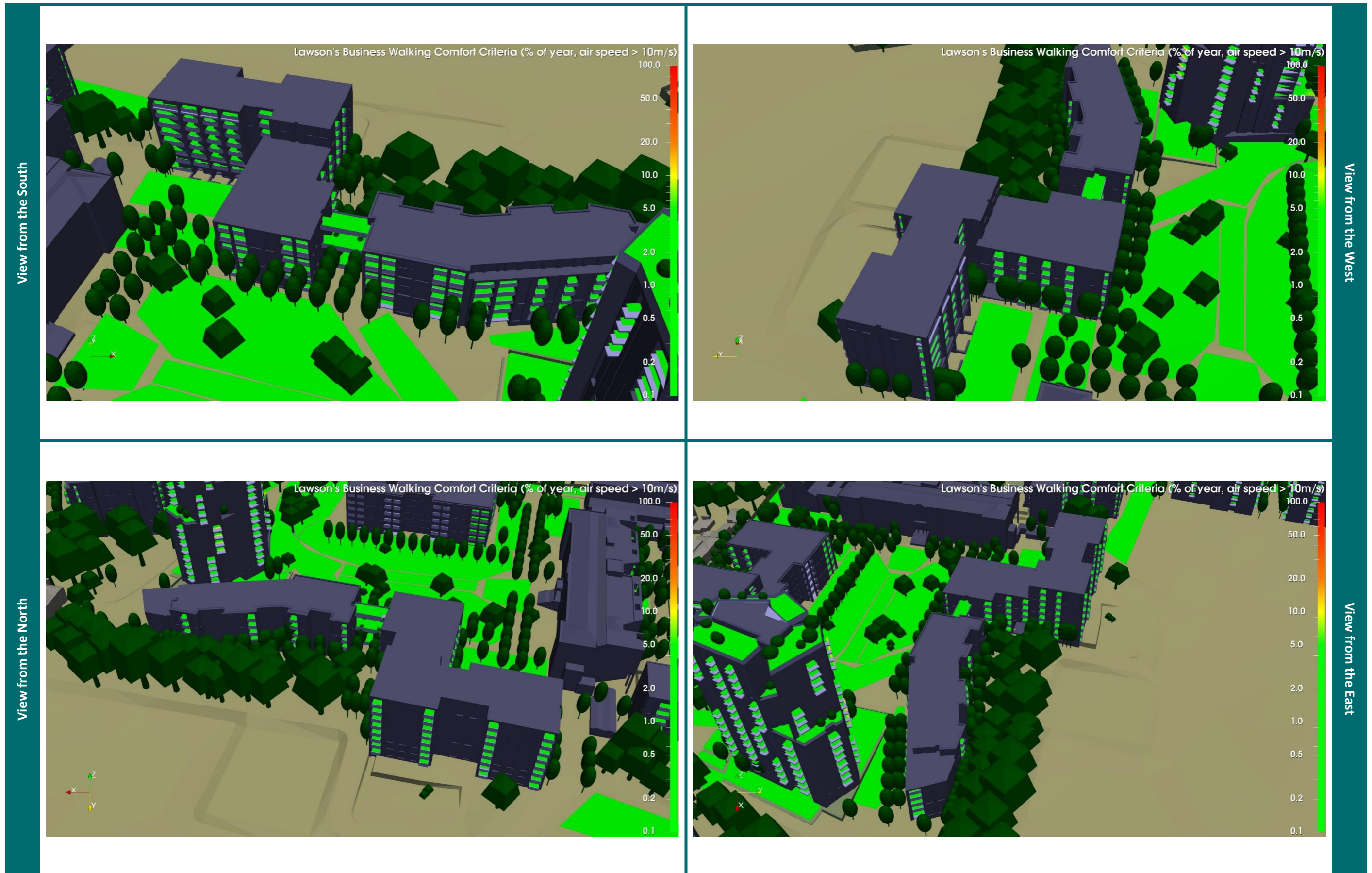


Figure 62: Business Walking Comfort Criteria: HJL Blocks B2 and B3

7.1.4.5 HJL Block C1

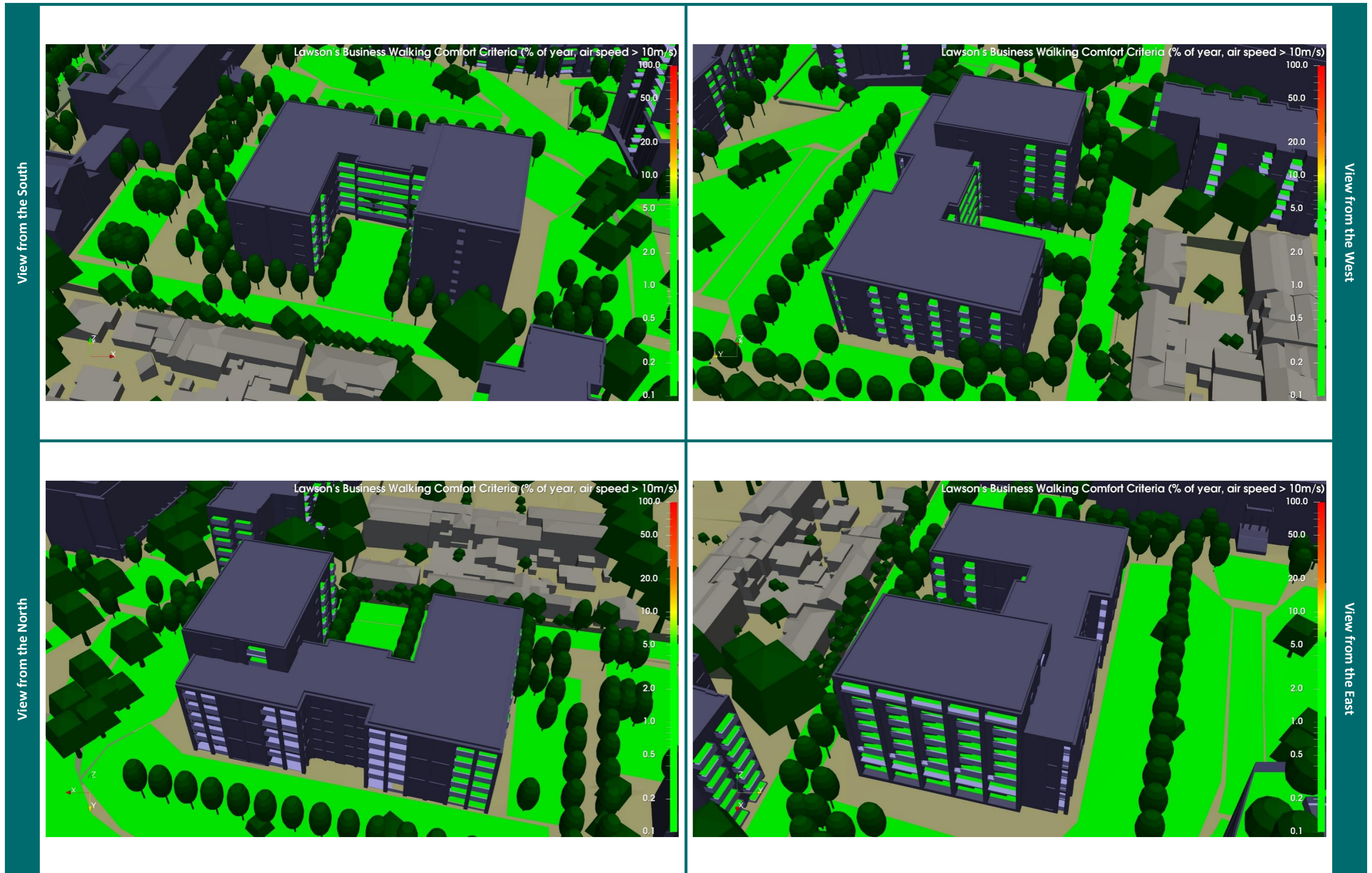


Figure 63: Business Walking Comfort Criteria: HJL Block C1

7.1.4.6 HJL Block C2

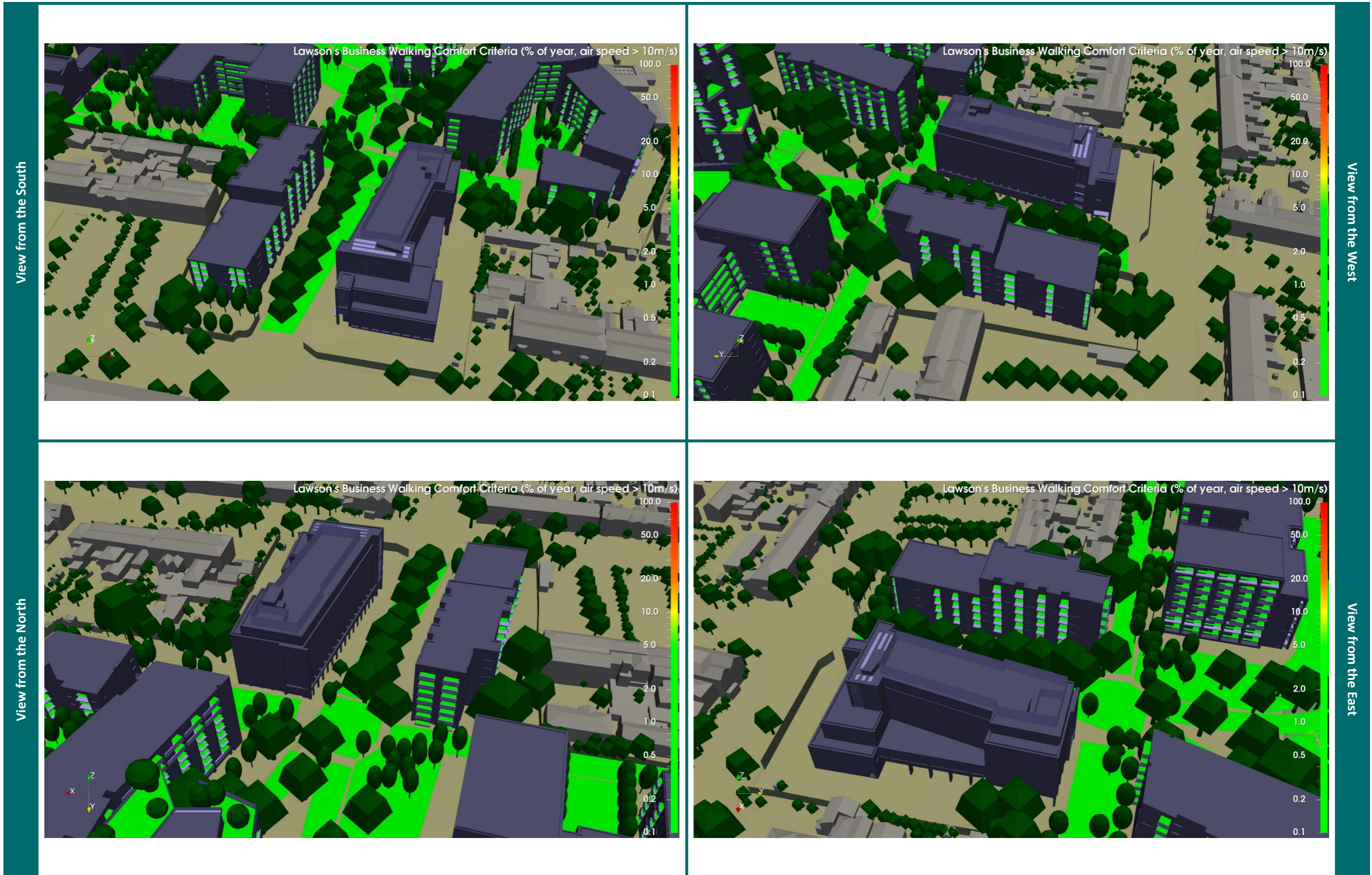


Figure 64: Business Walking Comfort Criteria: HJL Block C2

7.1.4.7 ODT Block D1

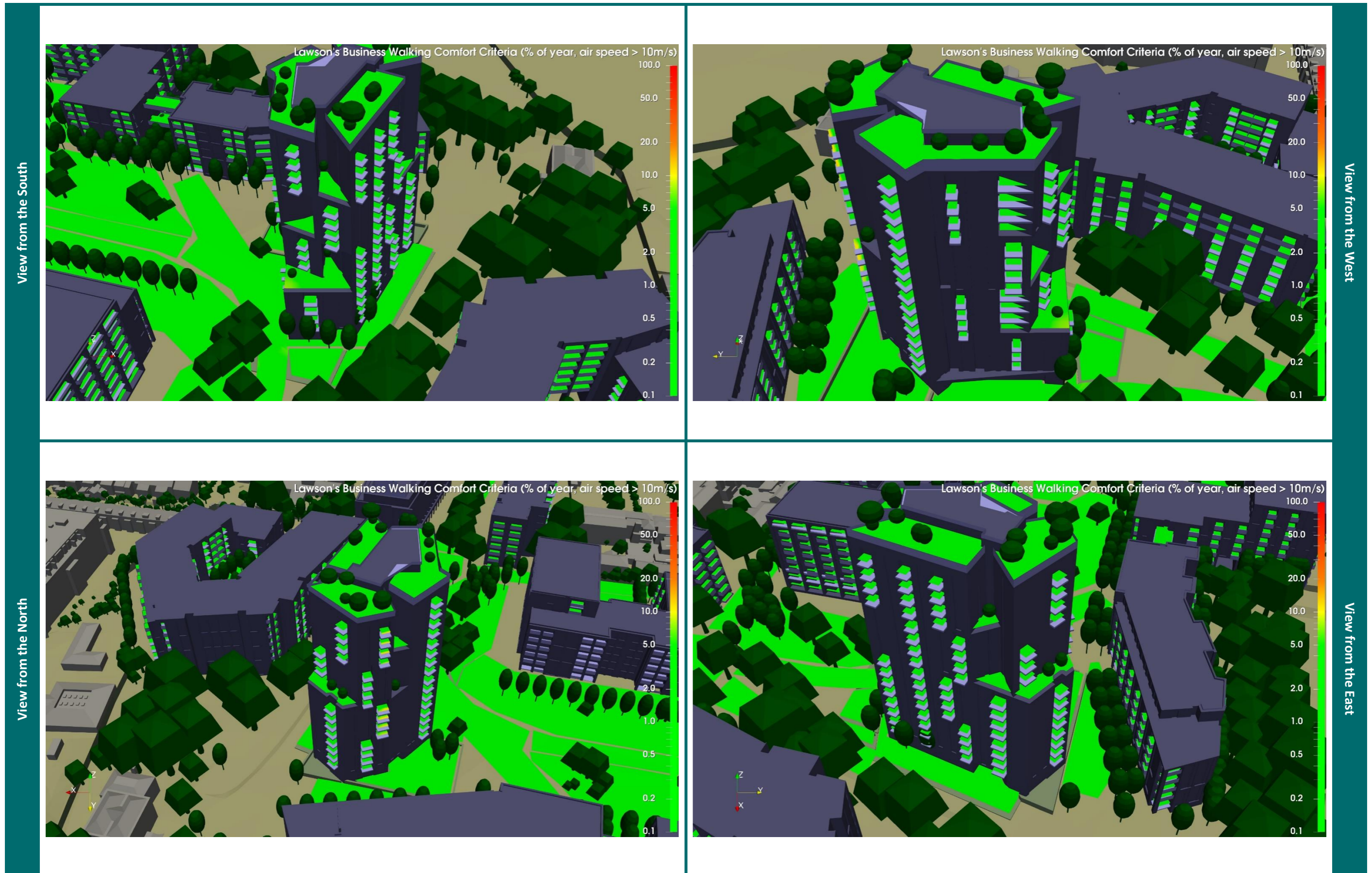


Figure 65: Business Walking Comfort Criteria: ODT Block D1

7.1.4.8 HJL Block D2

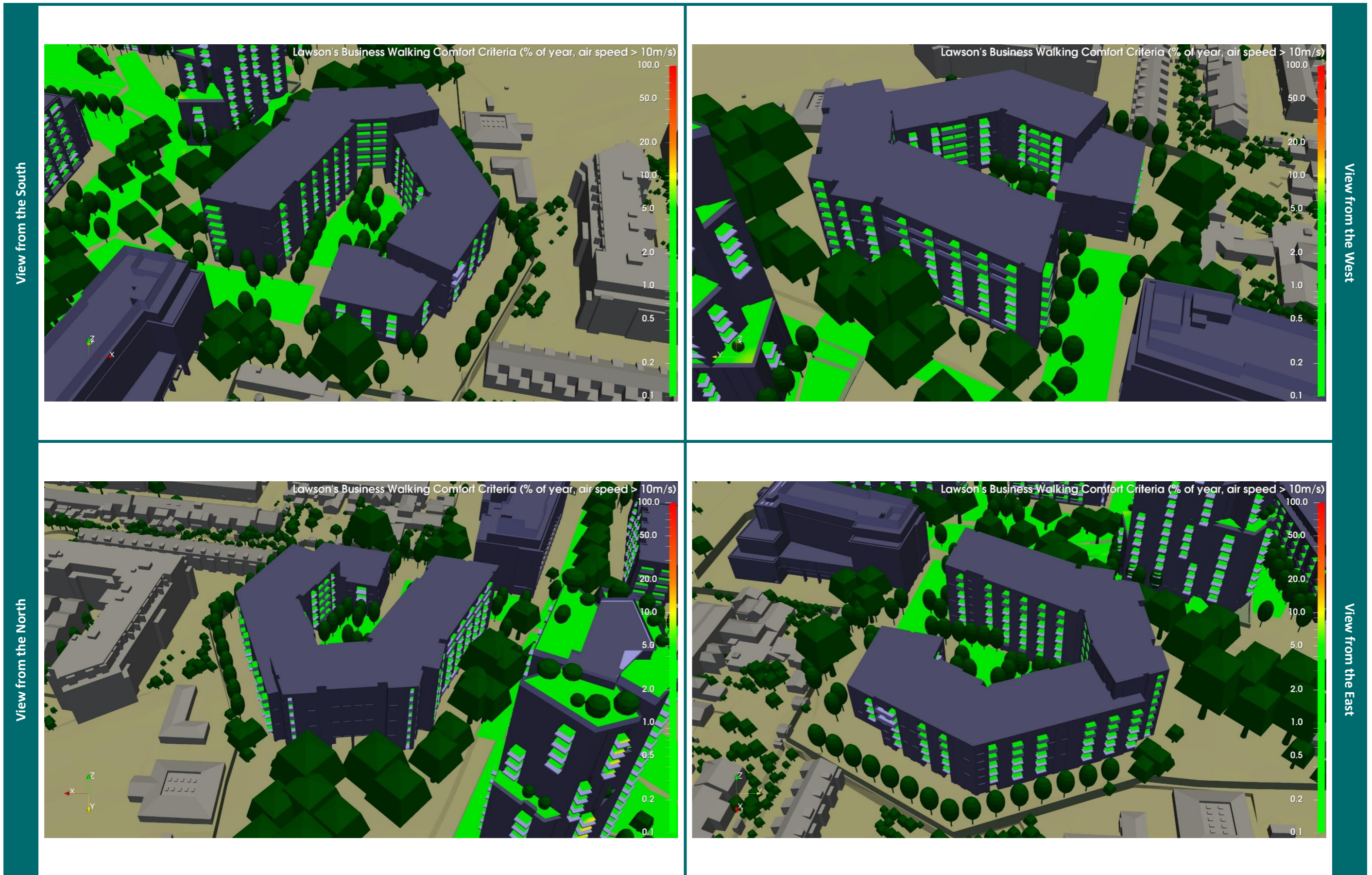


Figure 66: Business Walking Comfort Criteria: HJL Block D2

7.2 Safety Criteria: All Seasons

7.2.1 Normal Pedestrian Safety Criteria

Figures 67 to 74 show the percentage of the year the hourly wind speed exceeds the threshold value for the Normal Pedestrian Safety criteria for all seasons. The threshold value is 4m/s.

7.2.1.1 Overall Site

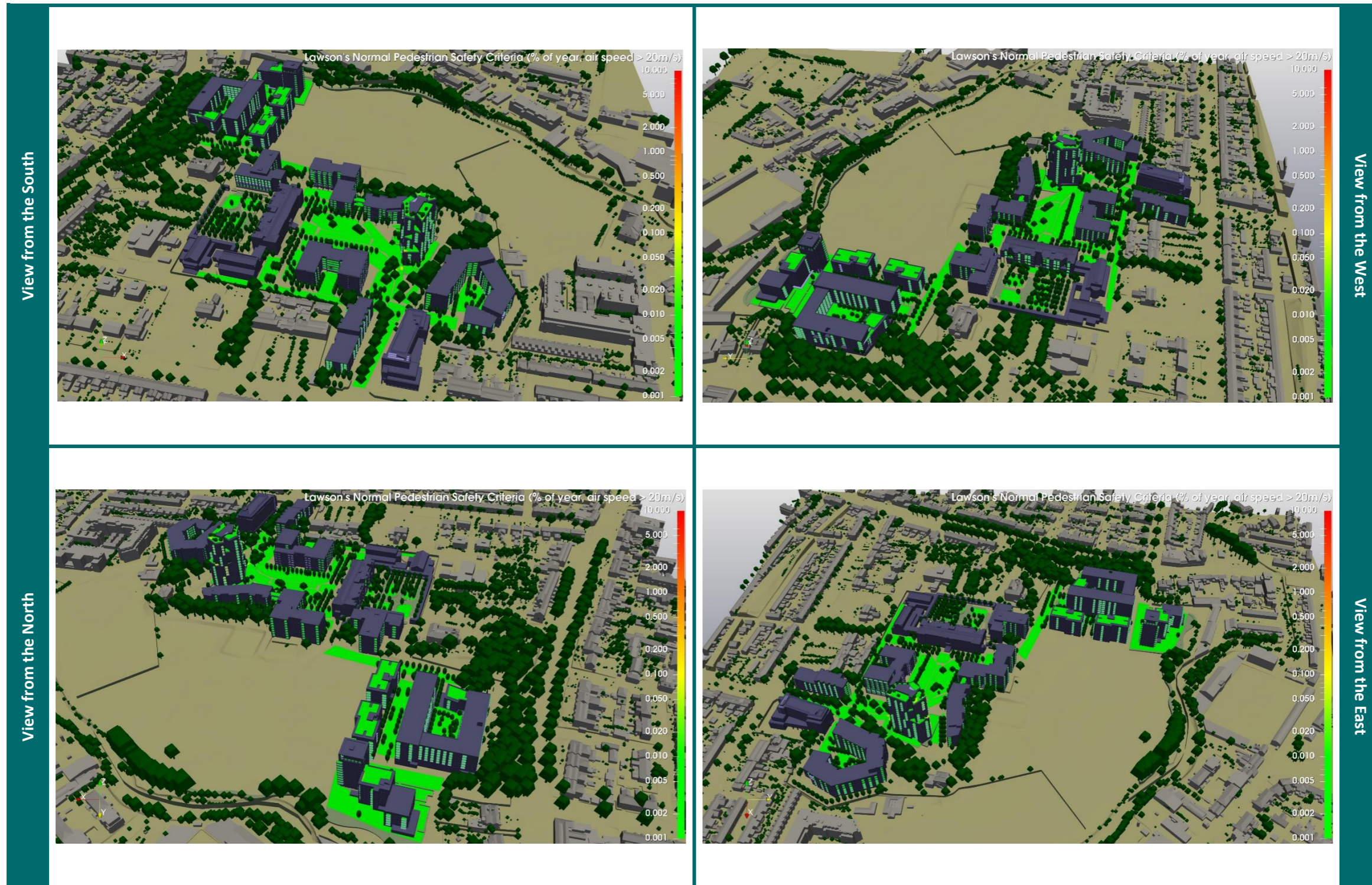


Figure 67: e Criteria: Overall Site

7.2.1.2 OMP Blocks A1 to A4

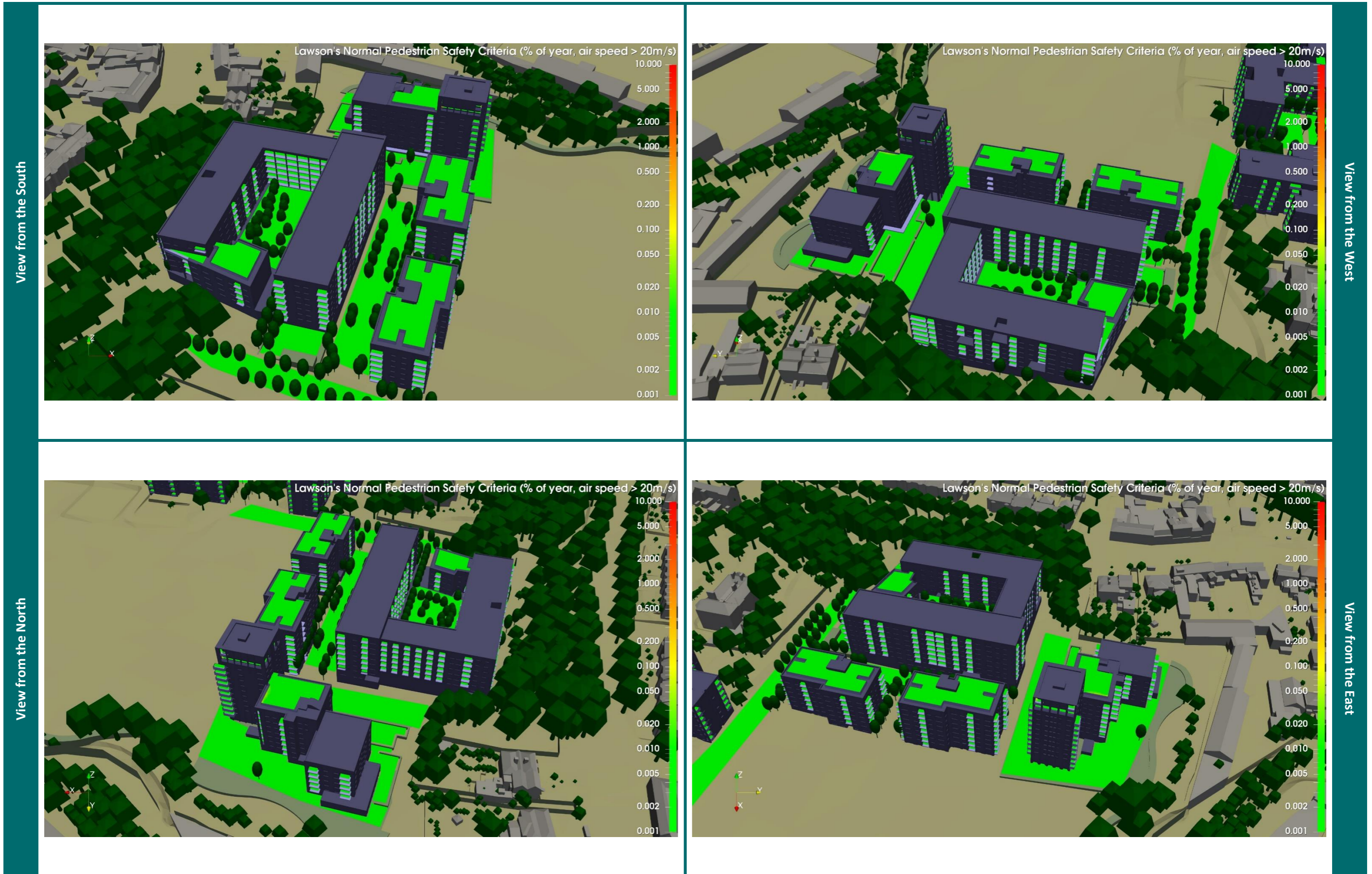


Figure 68: Normal Pedestrian Safety Criteria: OMP Blocks A1 to A4

7.2.1.3 HJL Block B1 and MCM Extension

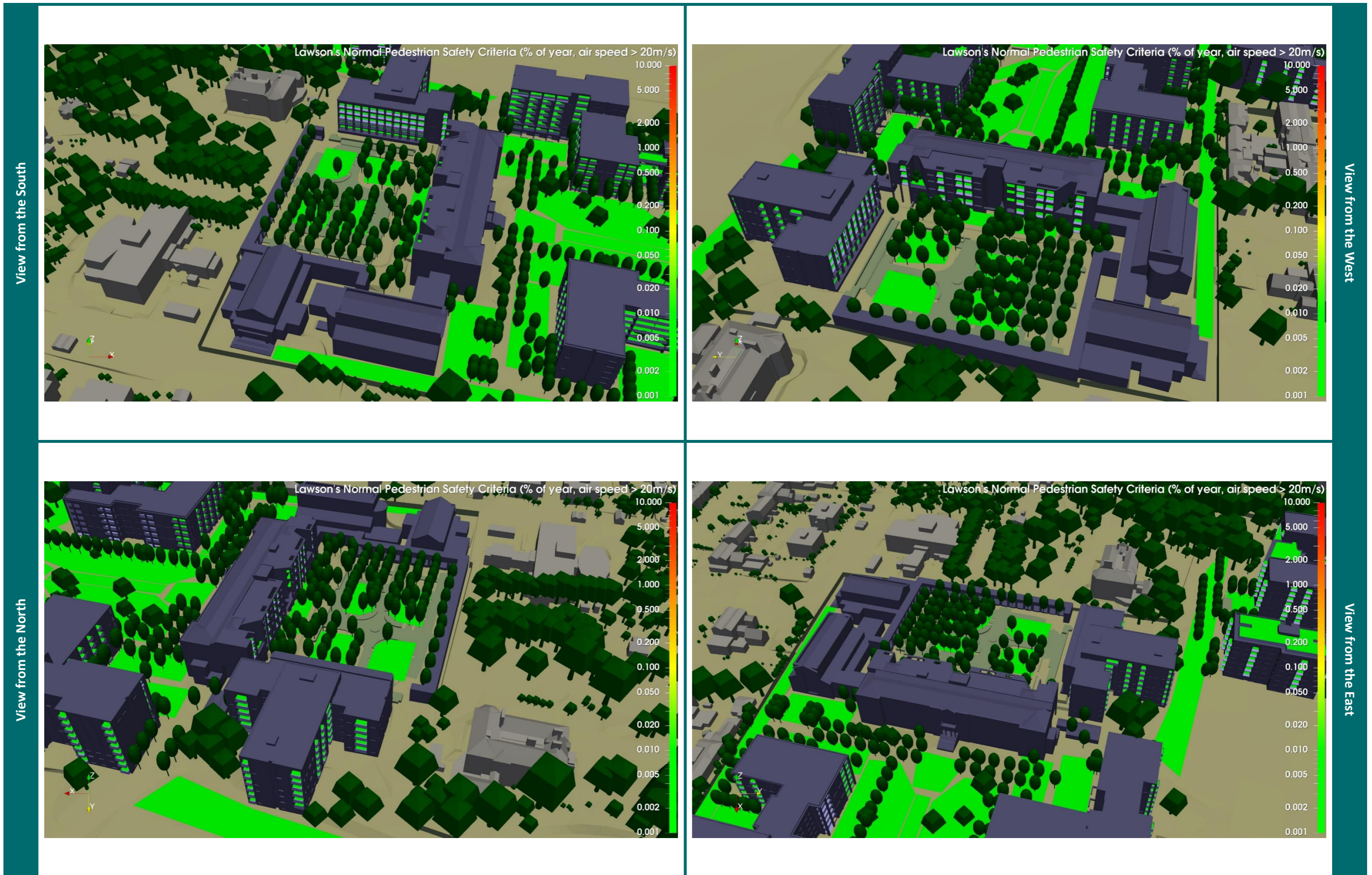


Figure 69: Normal Pedestrian Safety Criteria: HJL Block B1 and MCM Extension

7.2.1.4 HJL Block B2 & B3

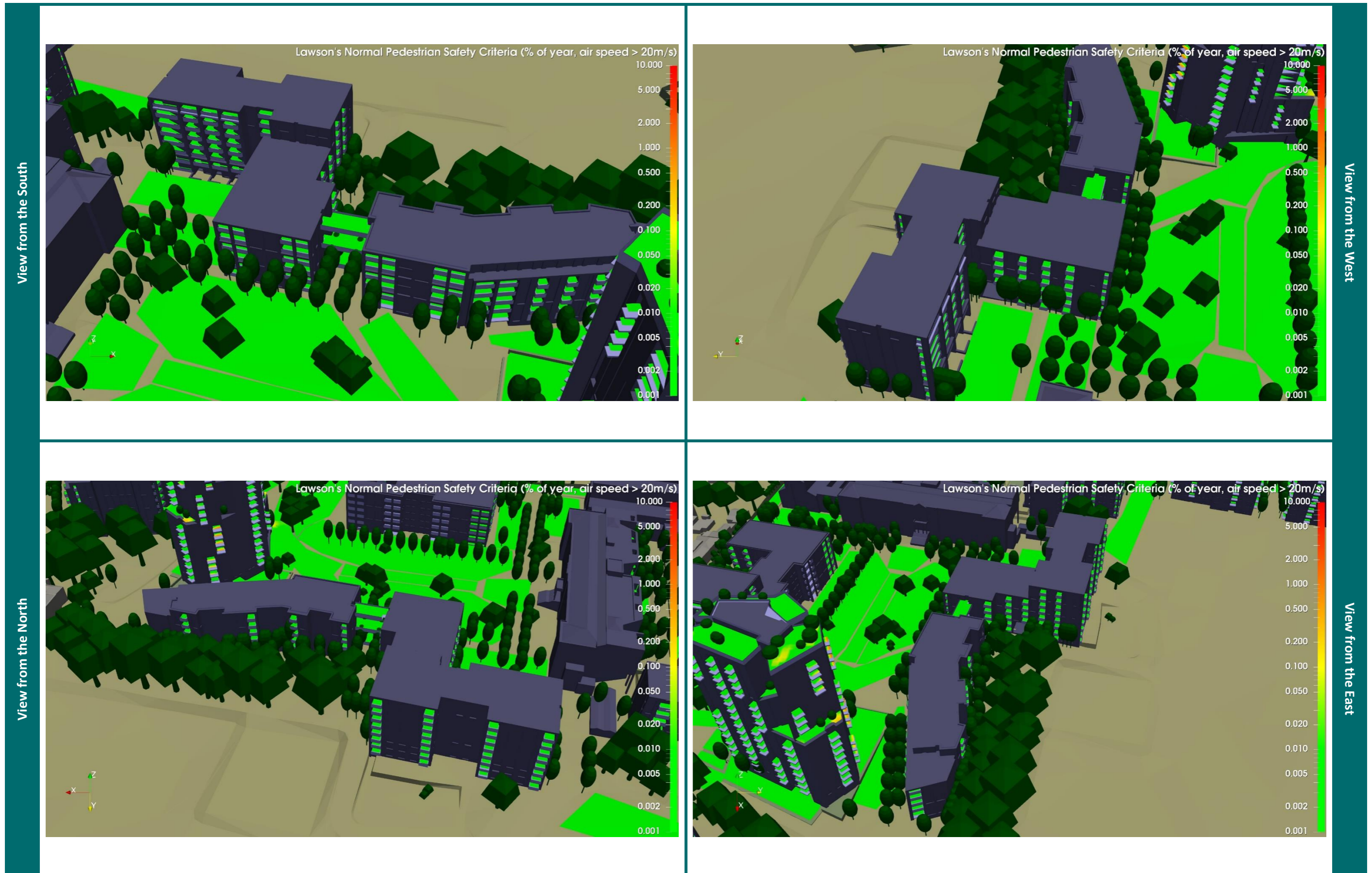


Figure 70: Normal Pedestrian Safety Criteria: HJL Blocks B2 and B3

7.2.1.5 HJL Block C1

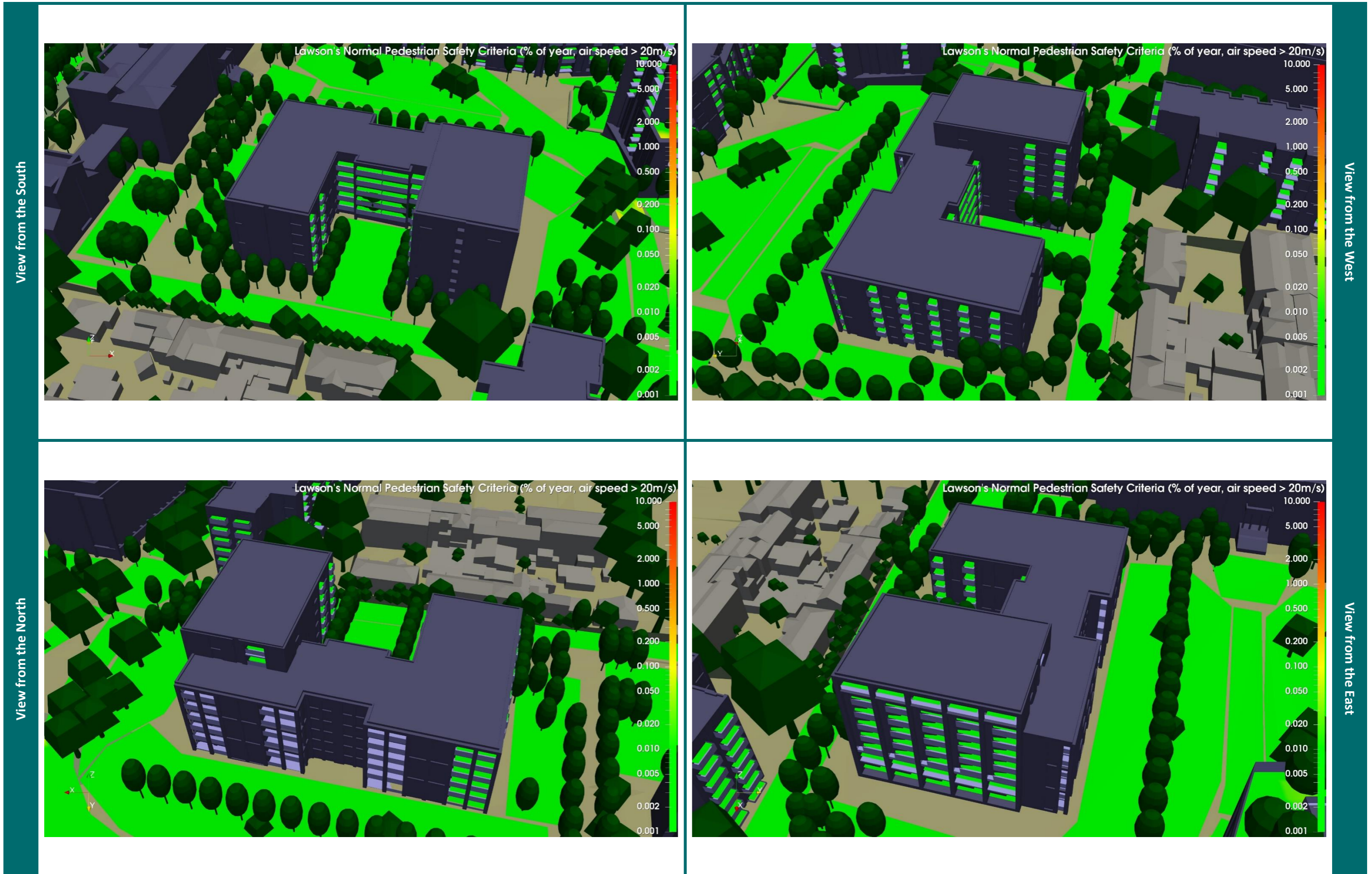


Figure 71: Normal Pedestrian Safety Criteria: HJL Block C1

7.2.1.6 HJL Block C2

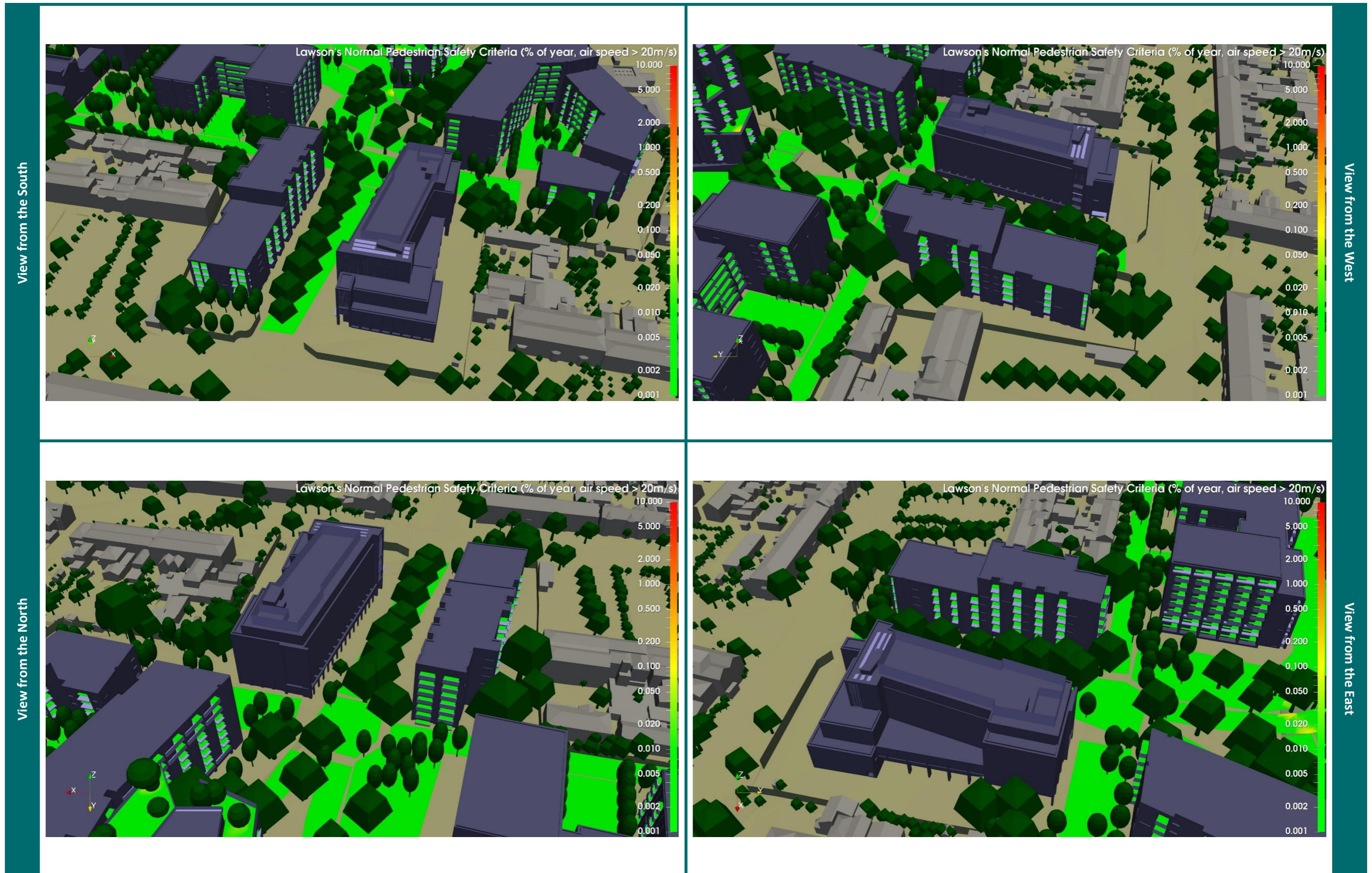


Figure 72: Normal Pedestrian Safety Criteria: HJL Block C2

7.2.1.7 ODT Block D1

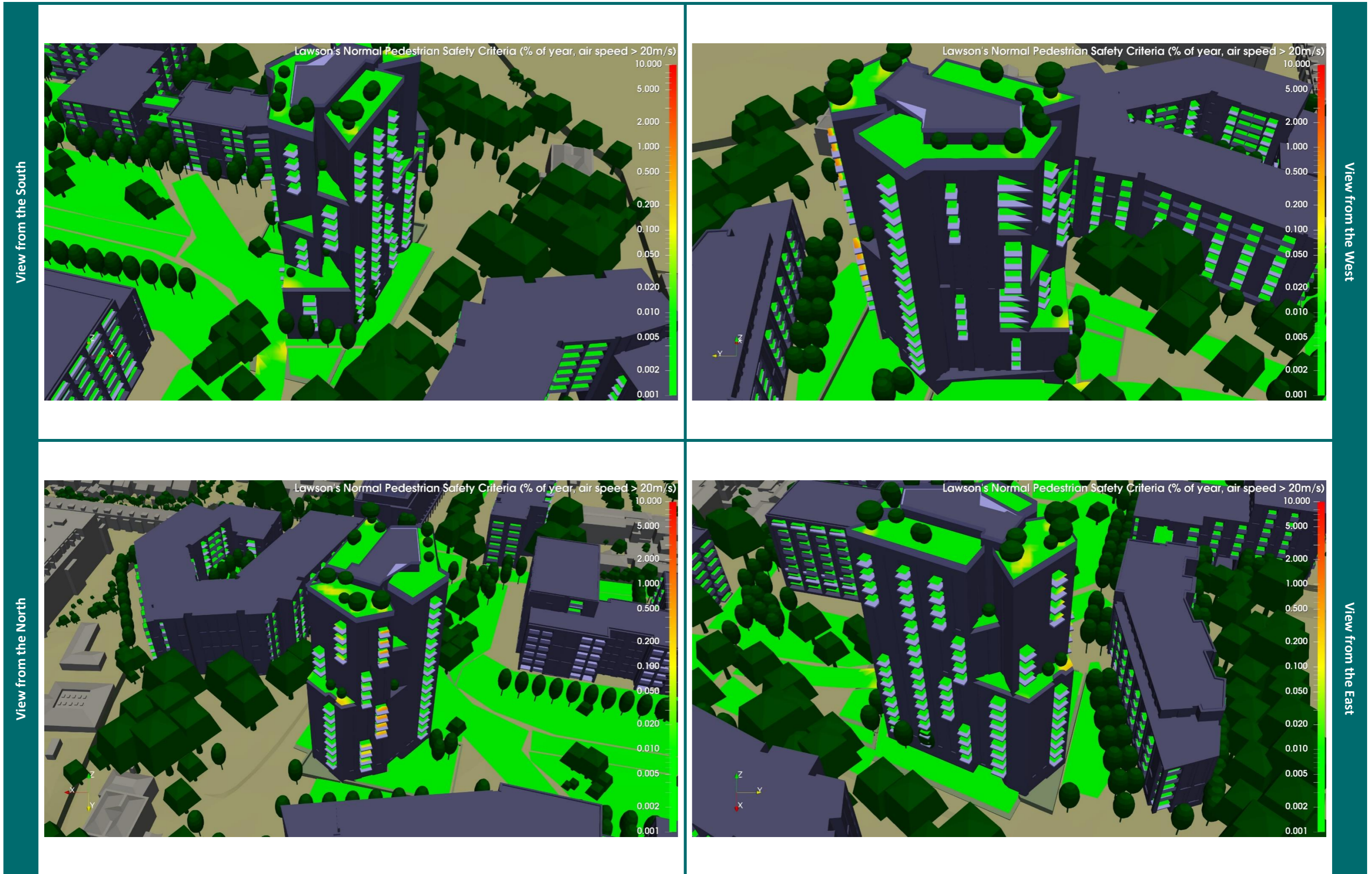


Figure 73: Normal Pedestrian Safety Criteria: ODT Block D1

7.2.1.8 HJL Block D2

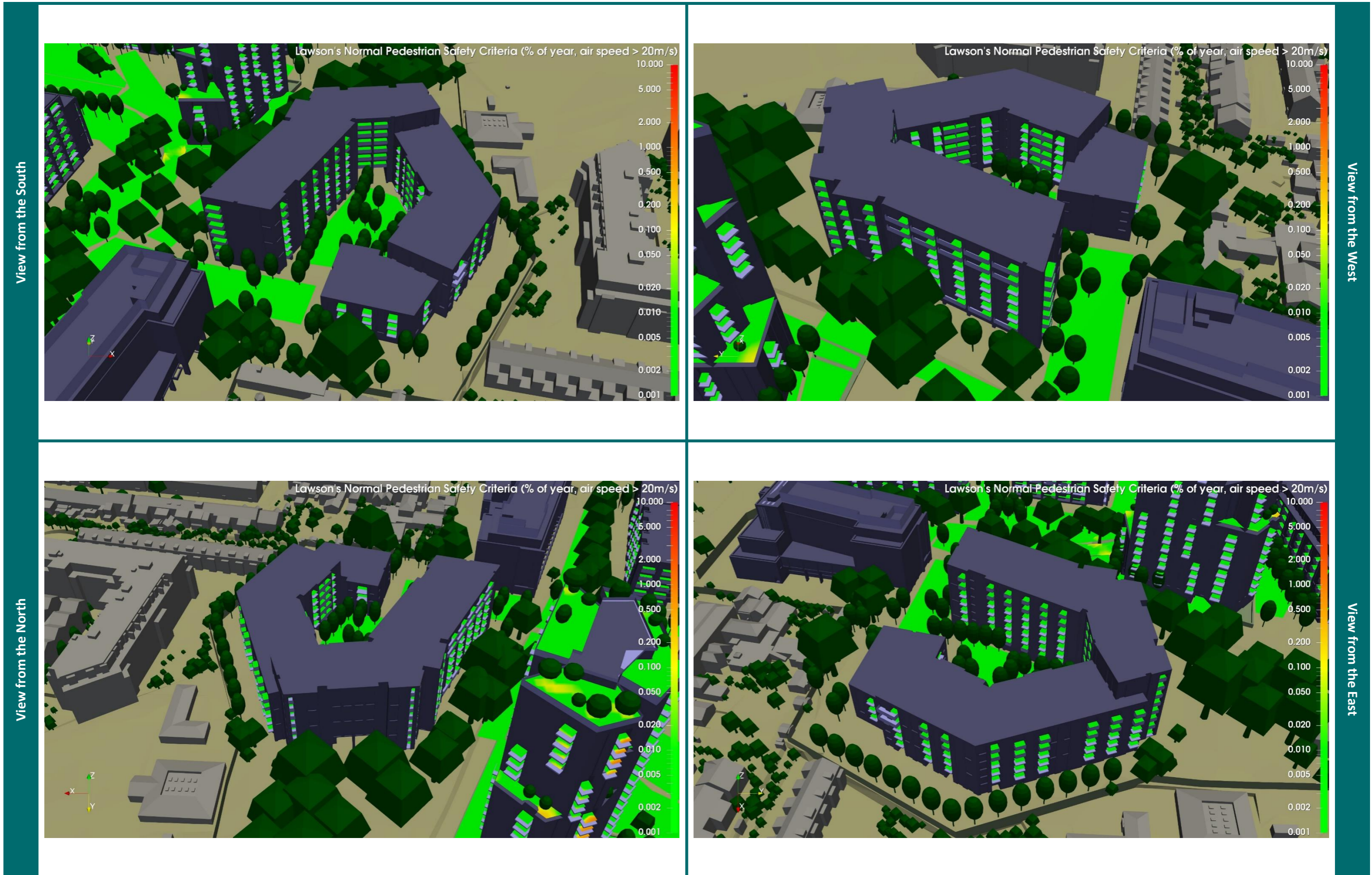


Figure 74: Normal Pedestrian Safety Criteria: HJL Block D2

7.2.2 Sensitive Pedestrian Safety Criteria

Figures 75 to 82 show the percentage of the year the hourly wind speed exceeds the threshold value for the Sensitive Pedestrian Safety criteria for all seasons. The threshold value is 4m/s.

7.2.2.1 Overall Site

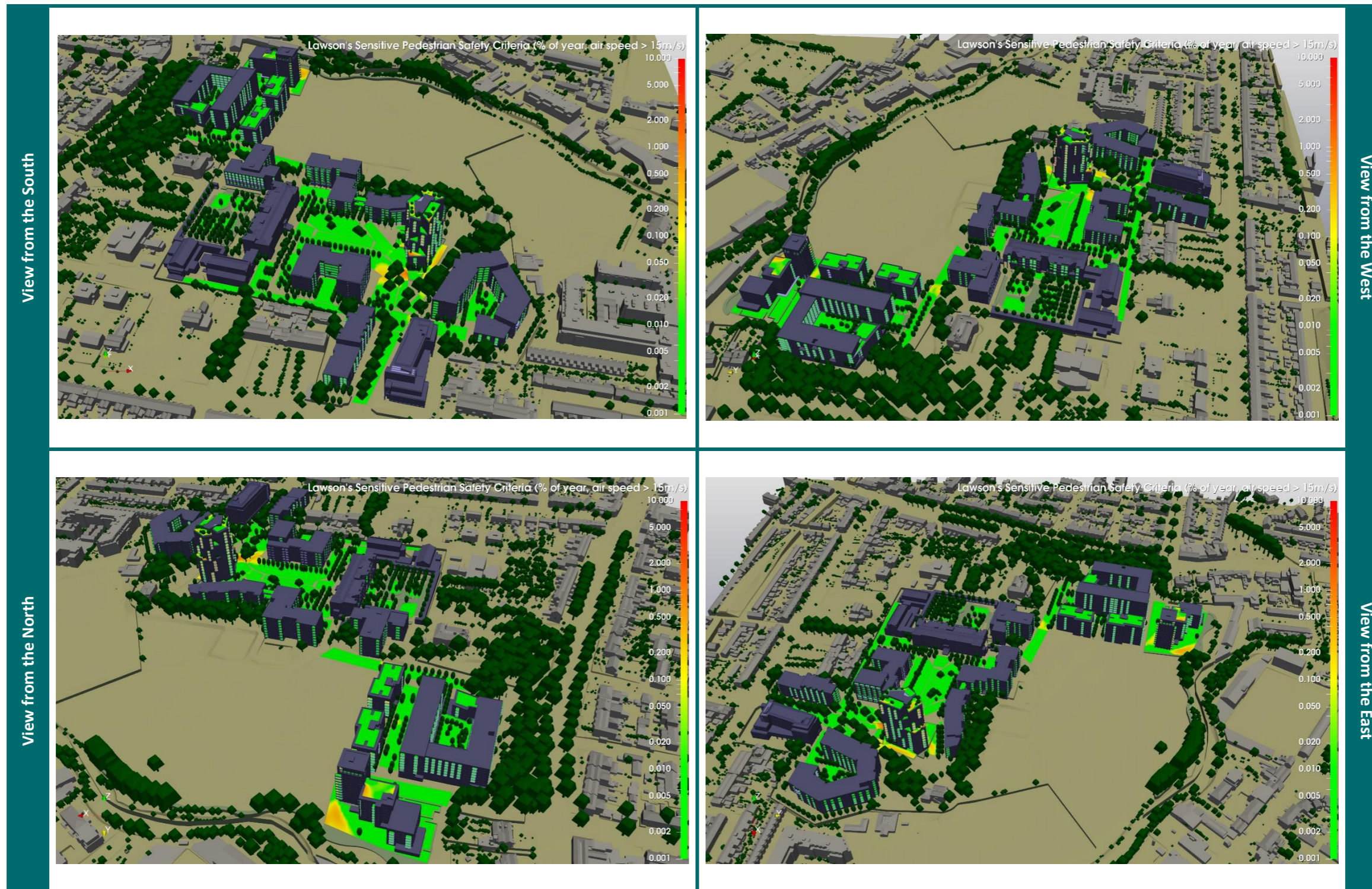


Figure 75: Sensitive Pedestrian Safety Criteria: Overall Site

7.2.2.2 OMP Blocks A1 to A4

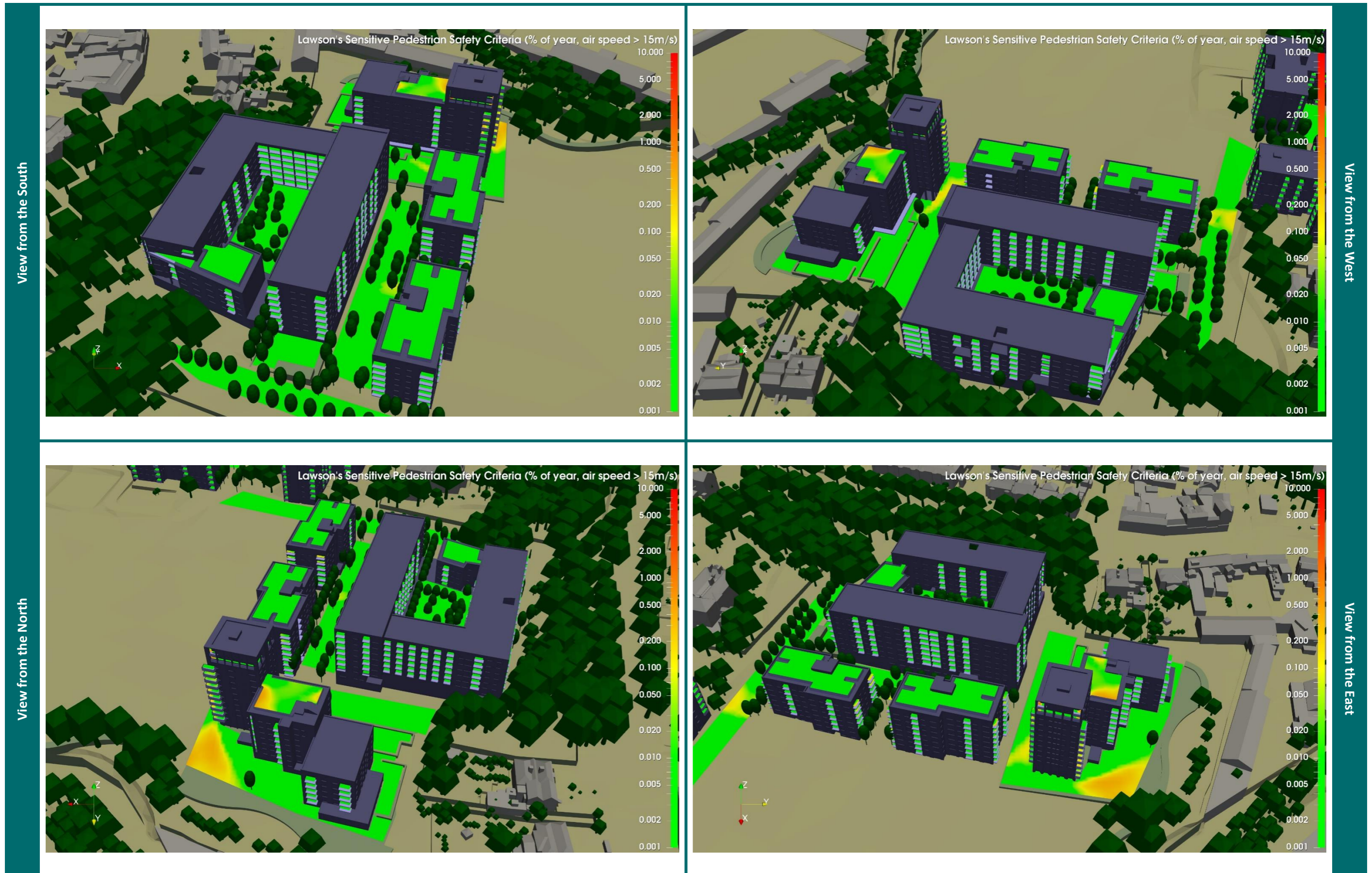


Figure 76: Sensitive Pedestrian Safety Criteria: OMP Blocks A1 to A4

7.2.2.3 HJL Block B1 and MCM Extension

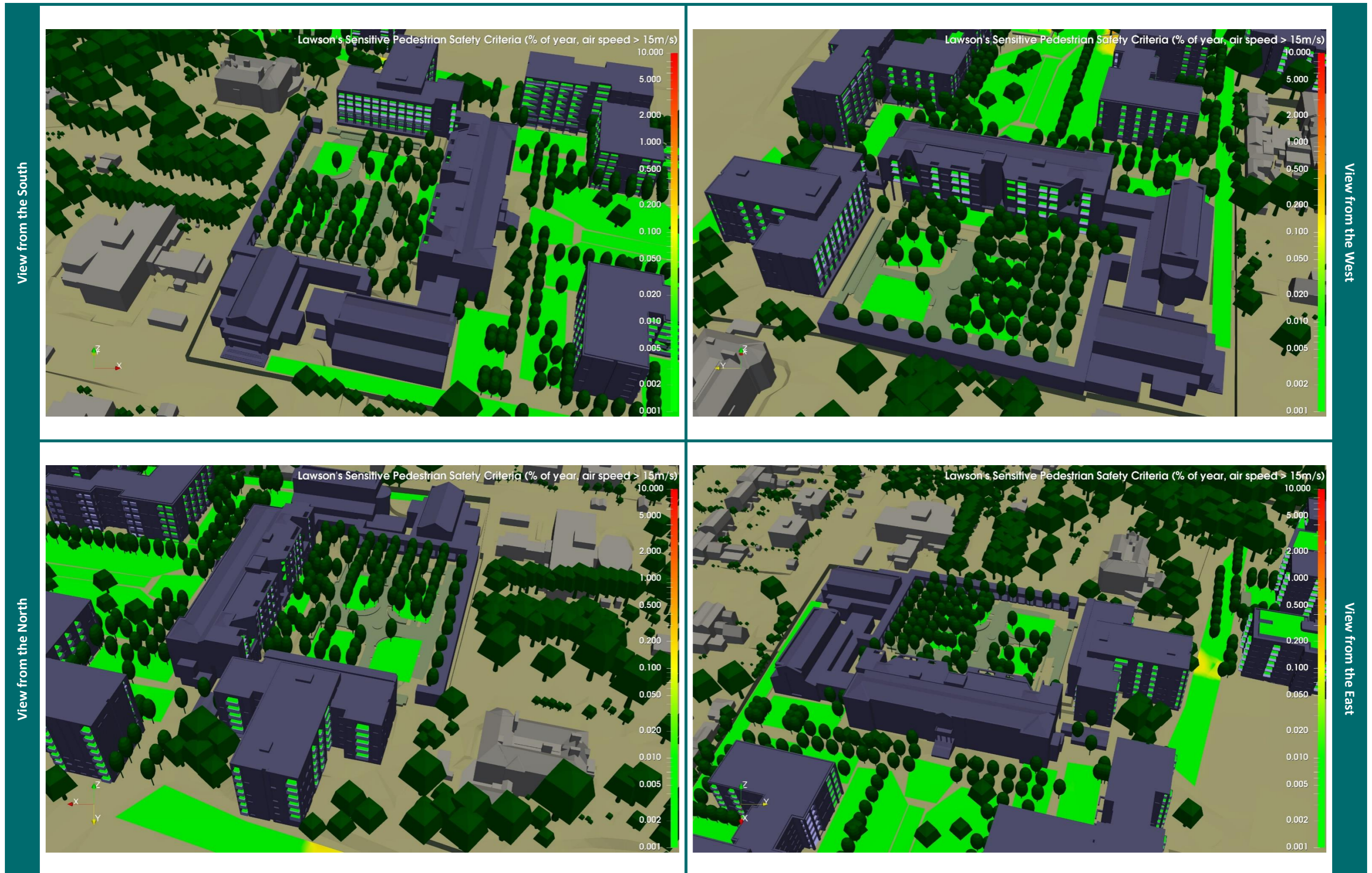


Figure 77: Sensitive Pedestrian Safety Criteria: HJL Block B1 and MCM Extension

7.2.2.4 HJL Block B2 & B3

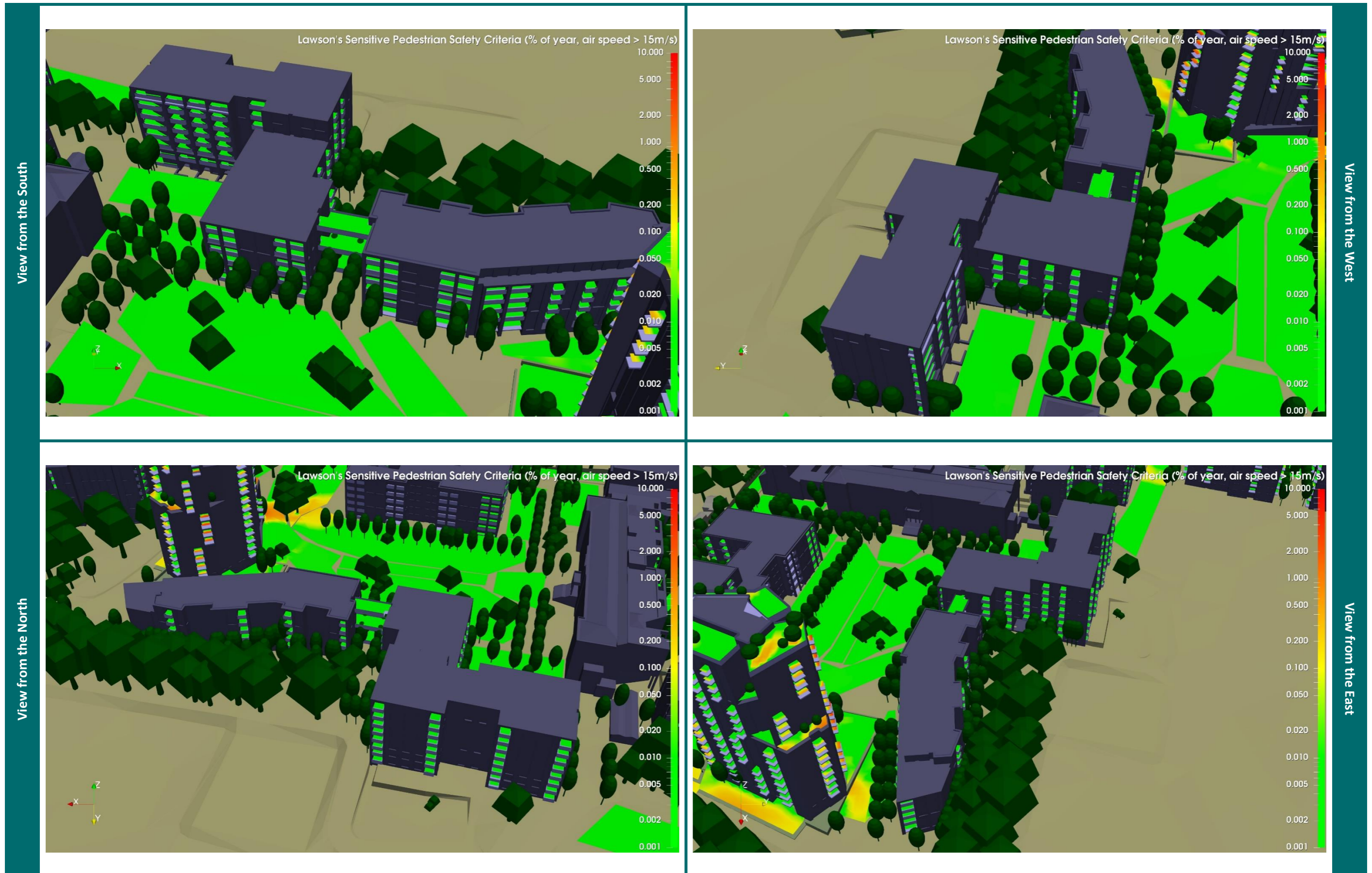


Figure 78: Sensitive Pedestrian Safety Criteria: HJL Blocks B2 and B3

7.2.2.5 HJL Block C1

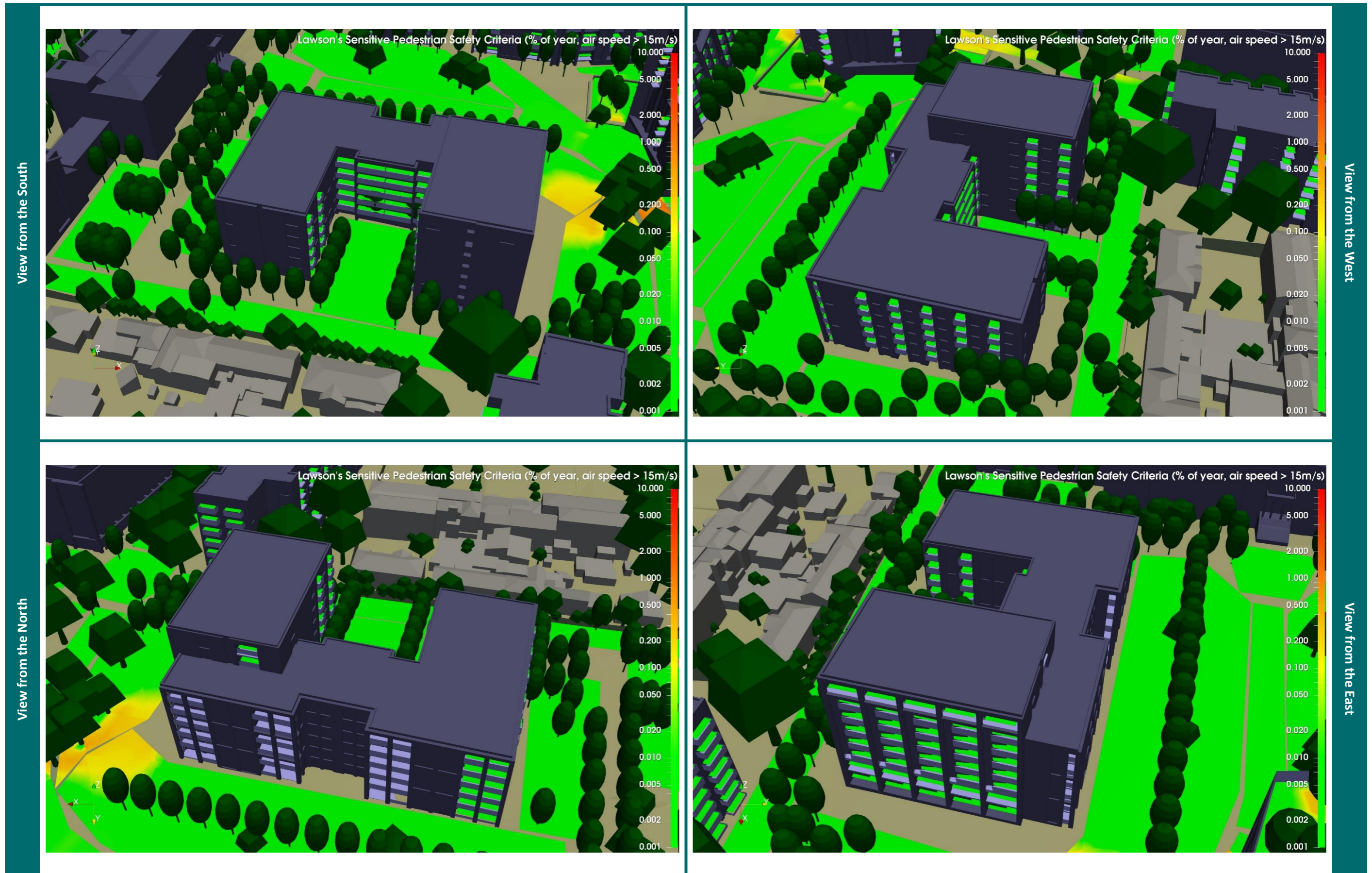


Figure 79: Sensitive Pedestrian Safety Criteria: HJL Block C1

7.2.2.6 HJL Block C2

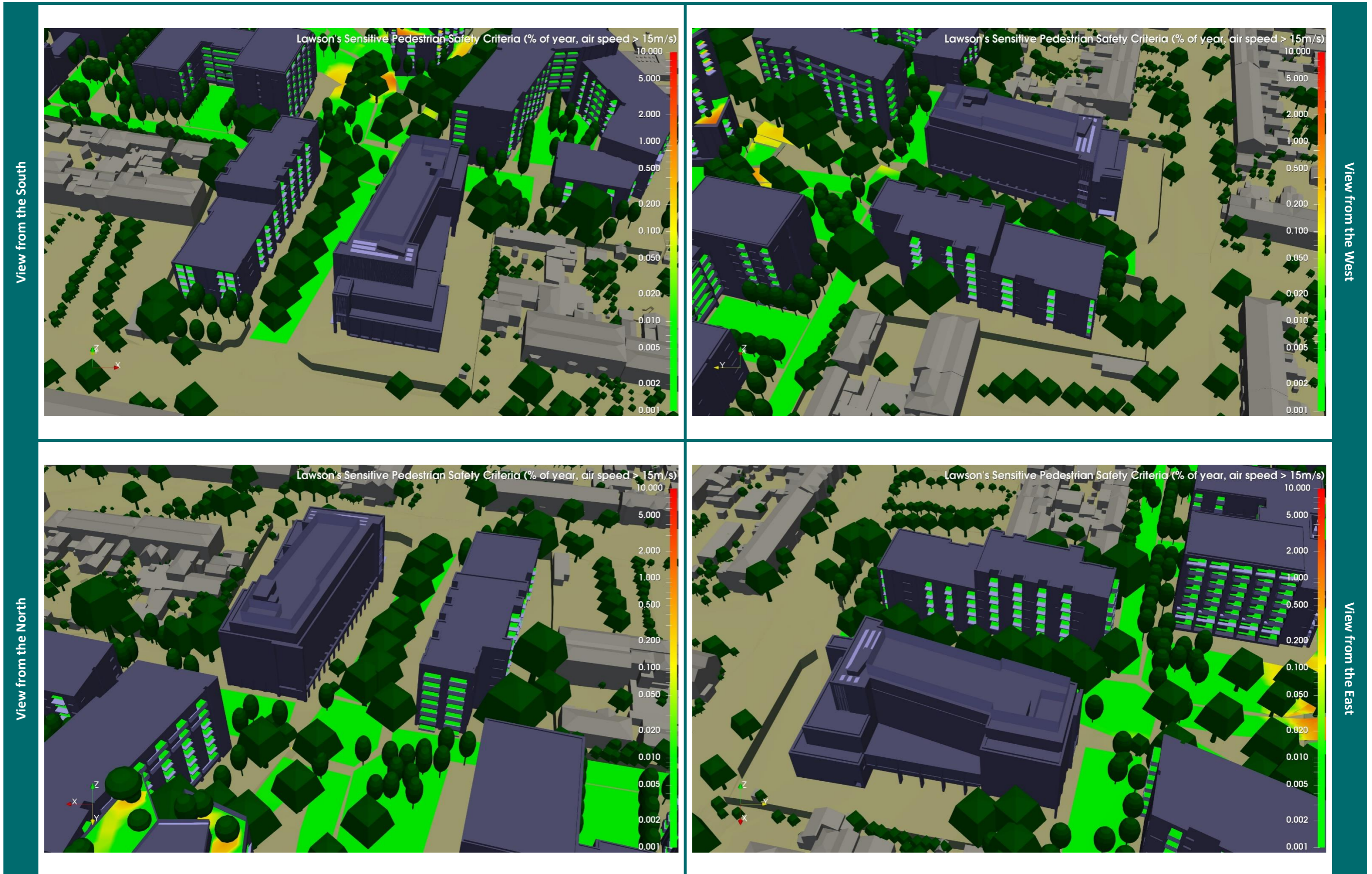


Figure 80: Sensitive Pedestrian Safety Criteria: HJL Block C2

7.2.2.7 ODT Block D1

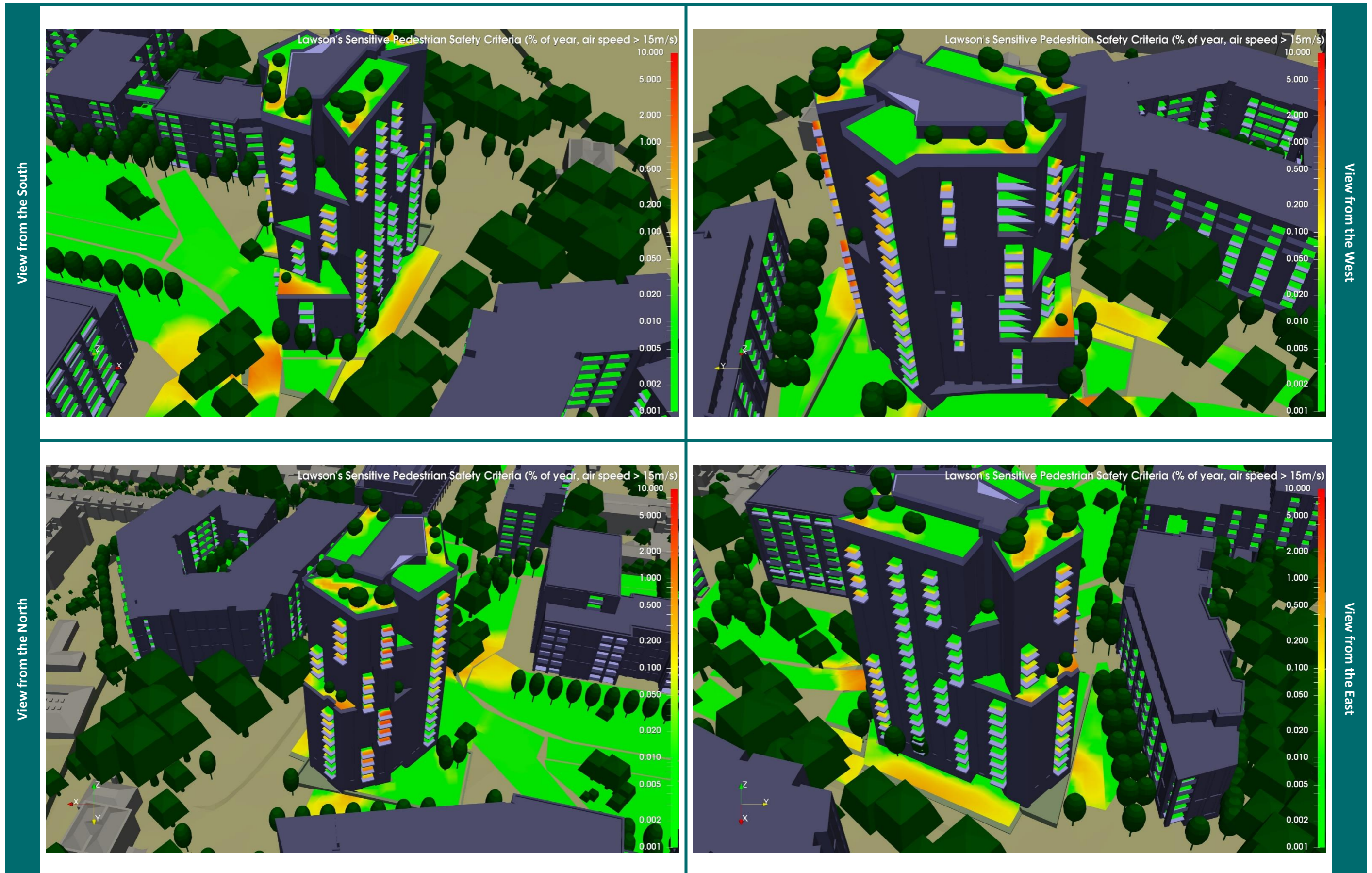


Figure 81: Sensitive Pedestrian Safety Criteria: ODT Block D1

7.2.2.8 HJL Block D2

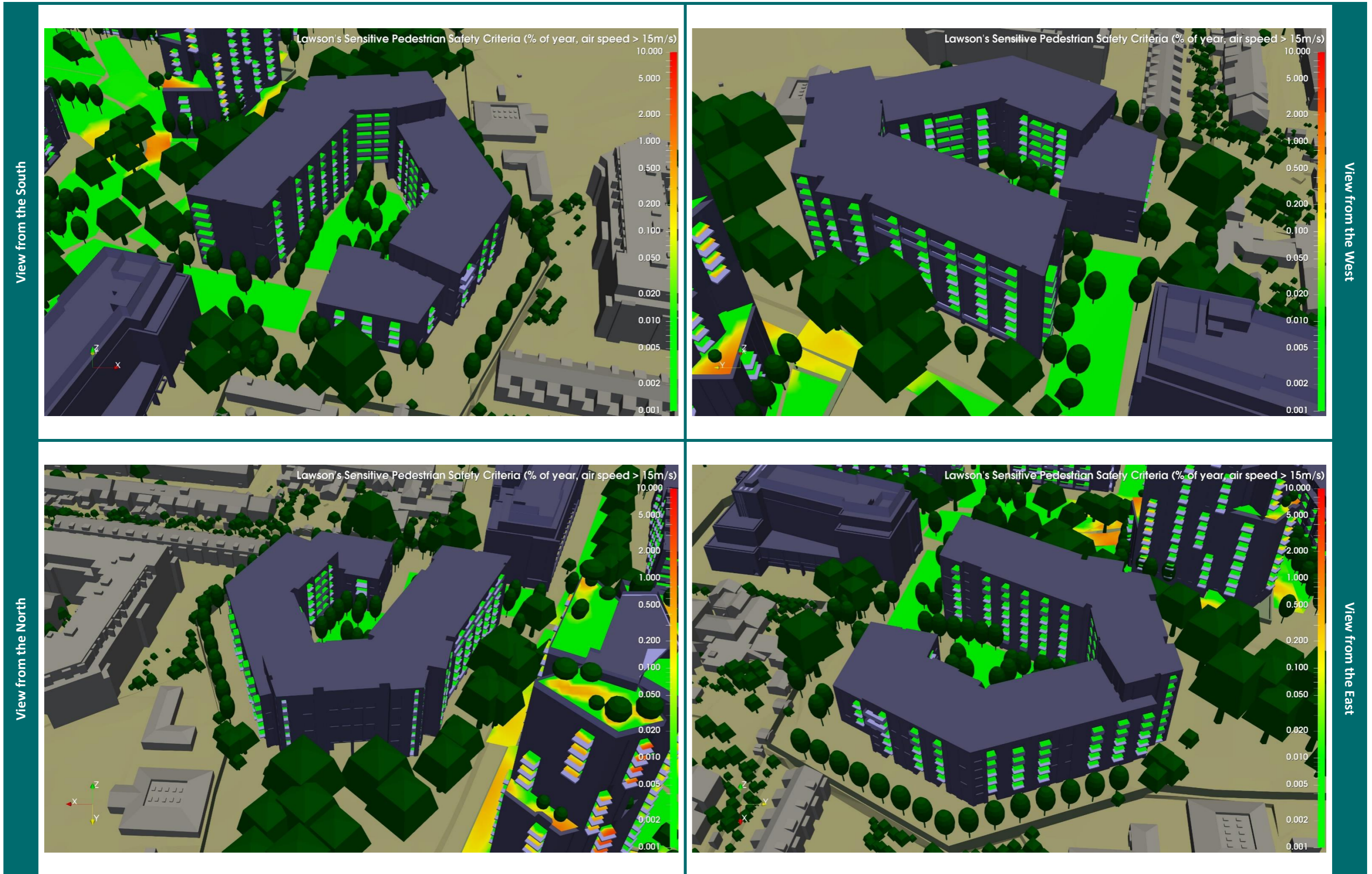


Figure 82: Sensitive Pedestrian Safety Criteria: HJL Block D2



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