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BRE Client Report

METRICS FOR DAYLIGHT CALCULATION: FINAL REPORT

Prepared for: BRE Trust and CIBSE
Date: February 2015
Report Number: 296307 Issue: 1

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Executive Summary

This report forms the final output of the BRE Trust project 210-14-RM 'Assessing new metrics for daylighting' and the CIBSE Research Fund project 'Assessing new methods for daylight prediction'. Accurate daylight calculation methods are important because they enable the designer to predict the lighting environment in buildings, the resulting energy consumption for lighting, and its input into the overall thermal performance of the building.

Two recent key developments have been the introduction of the Lighting Energy Numeric Indicator (LENI) and the use of climate based daylight modelling to obtain a picture of the overall, year round, daylight performance of a space. This report reviews these approaches to ensure that they can be used as the basis for robust, sophisticated daylight design guidance.

Traditional methods of daylight design rely on the daylight factor. This is the ratio of the daylight indoors to that on an unobstructed horizontal plane outdoors, under a standard overcast sky. The daylight factor is easy to calculate and it is a constant which depends only on the building. This makes it easy to use and apply as a design criterion. However it does not take account of the variations of daylight under sunny skies and does not vary with orientation. The daylight factor is therefore a poor metric to use in parts of the world where overcast skies are rare, or if there are special features such as light shelves, reflectors or prismatic glazing which make use of redirected sunlight.

Lighting use in daylit interiors depends on the type of control system as well as on the level of daylight provision. Lighting use can be calculated using a variety of methods, some of which are based on the daylight factor. They may include corrections for orientation and non-overcast skies.

The LENI is a method for predicting lighting energy use. It relies on equations given in EN15193 'Energy performance of buildings-Energy requirements for lighting' to predict daylight factors and the resulting lighting use for different control strategies. In this report, calculations from these equations were compared with the results of daylight modelling in example rooms. The analysis revealed various issues with the calculations in EN15193:

- The method of dividing the rooms into daylit and non-daylit zones can give artificial boundaries in some cases, which are unlikely to reflect the way electric lighting is controlled in practice.
- In the current EN15193, LENI values, being based on daylight factors, do not vary with orientation. This is proposed to be corrected in a future version of the standard.
- The calculated daylight factors using the EN15193 equations are in general lower than the average daylight factors in the daylit area. However this could be reasonable, because lighting would be normally be switched or dimmed according to the lowest daylight levels under each row of luminaires.
- The calculated daylight factors do not seem to vary enough with window width, and overestimate the effect of a courtyard or atrium.
- In reality, lighting use would be expected to vary smoothly with window area. However the EN15193 equations predict little or no change, then sudden drops in LENI as window area

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increases. Partly this is because of the way in which the LENI is not based directly on the daylight factor, but instead on a classification of daylight levels into 'low' 'medium' or 'high'; and partly because as window width increases, the daylit zone is larger and additional luminaires are assumed to be switched or dimmed.

- In the current EN15193, the savings from using automatic daylight linked controls do not depend on whether they are switching or dimming controls. This is proposed to be corrected in a future version of the standard. The savings tend to be overestimated in areas with switching controls and relatively low levels of daylight.

Climate based daylight modelling gives a much more sophisticated, and potentially more accurate, method to predict daylight provision and lighting use. It includes concepts such as daylight autonomy and useful daylight index to categorise daylight provision. Daylight autonomy is the proportion of the year (usually set operating hours within the year) for which daylight illuminance exceeds a particular value. Daylight autonomy has the advantage that it is directly linked to the savings that can be achieved from automatic daylight linked controls, and it includes the effects of orientation.

Useful daylight illuminance is the proportion of the year for which daylight illuminance falls within a 'useful' range. This approach has been questioned, particularly the idea that high illuminances automatically are not useful, and there is still uncertainty about what the useful range should be. Nevertheless, useful daylight illuminance is a potentially valuable metric, because it encourages the daylight designer to think about shading as an integral part of the daylight design process. In offices and school classrooms, its use tends to lead to designs with appropriate shading, good uniformity, and where possible high level glazing and either rooflights or windows in more than one wall.

In practice the definitions of daylight autonomy and useful daylight illuminance can vary. The target illuminance above which daylight is deemed sufficient, and the maximum illuminance, above which it is seen as excessive, can vary between authors and standards. The definition of yearly operating hours can vary according to the type of building. The metrics may refer to the illuminance at a particular point within the space (often a mid point), or an average illuminance over the whole space, or the proportion of points with a given daylight autonomy. Thus climate based daylight recommendations which look similar may result in quite different levels of daylight provision.

The detailed calculation methods used to generate daylight autonomy and useful daylight illuminance can affect the results obtained. Issues like the choice of grid size, the use of an offset excluding points close to the walls, the time step for calculation, the weather data file and assumptions about the way shading is operated can particularly affect useful daylight illuminance, as it is influenced by the best and worst lit areas in the room, and on illuminances on particularly bright and dull days. Future standards based on these quantities should give clear guidance on these calculation issues.

Recommendations based on the new metrics also need to take into account the type of space. Spaces which require higher illuminances, for example retail, tend to have lower daylight autonomy. Also, useful daylight illuminance may be a less appropriate metric in domestic type spaces where high illuminances could be welcome.

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Table of Contents

1 Introduction 5

2 Review of daylight metrics 6

2.1 Daylight factor 6

2.2 Calculating daylight in EN15193 8

2.2.1 Daylight supply factor 9

2.2.2 Daylight control factor 12

2.3 Climate based daylight modelling 13

2.4 Daylight autonomy 14

2.5 Useful daylight illuminance 16

3 Calculating electric lighting use in daylit interiors 20

3.1 General approach 20

3.2 Photoelectric switching 20

3.3 Photoelectric dimming 22

3.4 Manual control 23

3.5 Combinations of control types 24

4 Modelling daylight in example rooms 25

4.1 Method used 25

4.2 Large rooms 27

4.3 Small rooms 30

5 Assessment of LENI calculation in EN15193 33

6 Assessment of climate based daylight prediction 38

7 Conclusions 80

Acknowledgements 82

References 83

Appendix A Results of computer modelling 87

Appendix B Results of LENI calculations 97

Appendix C Results of detailed daylight metric calculations 104

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1 Introduction

Daylighting is a key element of sustainable building design. Daylight calculation methods are important to enable the designer to predict the lighting environment in buildings, the resulting energy consumption for lighting, and its input into the overall thermal performance of the building.

It is important that designers have accurate methods to predict daylight, and suitable benchmarks that are achievable but at the same time represent a good standard of daylight provision. Having inadequate daylight can result in gloomy interiors, poor contact with the outside, lack of view out, and high electric lighting use. However overglazing can lead to overheating and high cooling requirements, glare and excessive use of shading devices.

Two recent key developments have been the introduction of the Lighting Energy Numeric Indicator (LENI) and the use of climate based daylight modelling to obtain a picture of the overall, year round, daylight performance of a space. This report reviews these approaches to ensure that they can be used as the basis for robust, sophisticated daylight design guidance.

The LENI is a method for predicting lighting energy use. It relies on equations given in EN15193 'Energy performance of buildings-Energy requirements for lighting' to predict daylight factors and the resulting lighting use for different control strategies.

Climate based daylight modelling gives a much more sophisticated, and potentially more accurate, method to predict daylight provision and lighting use. It includes concepts such as daylight autonomy and useful daylight index to categorise daylight provision. These relate to the proportion of time that points in a room receive a particular daylight illuminance.

This report reviews these approaches and their associated metrics as well as more conventional metrics based around the daylight factor. It describes how electric lighting use in a daylit interior can be calculated under different types of lighting control. It compares the outputs of the metrics in EN15193 with computer methods in example rooms.

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2 Review of daylight metrics

2.1 Daylight factor

Recommendations on daylighting in buildings are given in BS 8206 Part 2 (ref. 1), the newly revised CIBSE SLL Lighting Guide (ref. 2), and the BRE Report 'Site layout planning for daylight and sunlight: a guide to good practice' (ref 3). Another BRE report (ref. 4) gives detailed design advice.

These recommendations are based on the daylight factor, which has been the most widely used daylight metric for many years. The daylight factor at a point is the ratio of the internal daylight illuminance to the corresponding horizontal unobstructed external illuminance. Both internal and external illuminances are taken under the same reference sky luminance distribution which is almost always the CIE standard overcast sky.

The daylight factor has three components: the sky component (light received directly from the sky); externally reflected component (light reflected from external obstructions) and internally reflected component (received after reflection from internal surfaces).

Since the standard overcast sky does not vary with azimuth, the daylight factor does not depend on window orientation or sun position. It is solely a function of building geometry and reflectances. Point daylight factors depend on position in the room, typically with very high values close to a window and much lower values at the back of a room.

The mean of all the point daylight factors on the working plane in a room is the average daylight factor DF. This is widely used in design guidance (refs 1-4) to quantify the overall amount of daylight in a space. A key advantage of the average daylight factor is that it can be represented by a simple formula:

$$DF = \frac{W\ T\ \theta}{A\ (1-R^2)} \quad (\%)$$

where W is the glazing area.

T is the glass transmittance.

θ is the angle (in degrees) of sky visible from the centre of the window measured in a vertical section through the window. With no obstruction, θ is 90º for a vertical window. Big obstructions outside can lower θ significantly.

A is the area of all room surfaces (ceiling, floor, walls and windows).

R is their average reflectance.

The equation can be inverted to give the required window area for a particular average daylight factor.

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The BS code (ref 1) recommends that 'if electric lighting is not normally to be used during daytime, the average daylight factor should be not less than 5%. If electric lighting is to be used throughout daytime, the average daylight factor should be not less than 2%.' According to the BS, these recommendations should be adopted 'where a predominantly daylit appearance is wanted.'

These recommendations have been widely adopted in other daylight design guidance, for example SLL's Lighting Guide 'Daylighting and Window Design' (ref 2); the BRE guidance on site layout planning (ref 3) and the environmental labelling scheme BREEAM (ref 5). If used in the development of a real building, the 5% average daylight factor criterion sets an important constraint on design. While 2% average DF is fairly easy to achieve, 5% often requires unusually large window areas in side lit rooms, particularly if the space is at all deep.

In continental Europe, point daylight factors, for example in the middle of a room, are more widely used. Point daylight factors are more difficult to calculate and cannot be used to generate a window area in the same way that the average daylight factor formula can (the equation for average daylight factor can be inverted to give the window area required for a particular average daylight factor). However a drawback of average daylight factor is that it depends a lot on the very high illuminances close to the window. Features such as overhangs or light shelves have a disproportionate effect on average daylight factor because they cut these high illuminances while having little or no effect on illuminances further from the window, which are more important for the overall daylighting of the space. For this type of situation a point daylight factor at the middle or rear of the room may give a better overall assessment of the daylight in the space and the effect of the overhang or light shelf.

As a metric, the daylight factor has two important advantages; it is a constant which depends only on the building, and it is readily calculated using a variety of methods. This makes it easy to use and apply as a design criterion. It can also be argued that as the daylight factor relates to a worst case sky condition (the overcast sky) designing to it means that most of the time a building will be better lit than expected. However the daylight factor has been criticised for a number of reasons:

i. Under non-overcast skies the daylight factor is not a constant, but depends on sky conditions. Measured illuminance ratios often vary by a factor of two or three (ref 6). Even under cloudy conditions, the daylight factor tends to underestimate actual illuminance ratios in side lit rooms (ref 7).

ii. Under non-overcast skies the daylight factor varies with orientation. A south facing window admits more than one and a half times the diffuse daylight of a north facing window, and over twice as much if sunlight is taken into account as well as daylight (ref 8).

iii. The daylight factor is therefore a poor metric to use in parts of the world where overcast skies are rare (ref 9).

iv. The daylight factor does not take into account the full contribution of innovative daylighting systems (ref 10) which are designed to control and use sunlight as an effective working illuminant, such as light shelves, light pipes, reflective blinds and louvres or prismatic glazing.

v. Daylight illuminances, rather than daylight factors, are a better measure of subjective satisfaction with daylight. Early advocates of the daylight factor took the opposite view, because of the adaptation of the eye to high illuminance levels. For example Waldram (ref 11) stated 'The eye is affected by ratio only, and is scarcely aware of huge variations in amount'. However Phillips (ref 12) concluded that the data on which Waldram's argument was based had been poorly analysed, and in fact showed a dependence on illuminance. Other studies (see for example refs 13, 14) have indicated that the daylight illuminance is a better measure of when people decide that daylight is inadequate and switch the lighting on. This appears logical because in real buildings people switch lighting on as daylight illuminances decrease, even though the daylight factor remains constant.

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vi. Using too high a daylight factor can lead to overglazing, overheating and glare, with consequent overuse of blinds (ref 9).

2.2 Calculating daylight in EN15193

EN15193 “Energy performance of buildings – Energy requirements for lighting” (ref 15) is the European Standard for assessing the lighting energy performance of buildings. It involves calculation of the Lighting Energy Numeric Indicator (LENI). LENI gives a value in terms of the energy use per metre squared for a given time period (usually one year). The energy use for a building, or space in question, is calculated from the total of the energy used for illumination purposes plus the parasitic energy (this is the standby energy used by the lighting controls in the space). The energy use for illumination is estimated from the sum of wattages of the luminaires (lamps plus any ballast) used in the space, modified by various dependency factors. These factors are the occupancy dependency factor (F_o), constant illuminance factor (F_c) and daylight dependency factor (F_D). There is currently a draft 2014 revision of EN15193 (ref 16), and accompanying draft Technical Report (ref 17). This section describes how EN15193 calculates this daylight dependency factor. In the draft revision of EN15193 some notation is different from the current version as used below.

The daylight dependency factor is defined as:

$F_D = 1 – (F_{D,S} \text{ X } F_{D,C})$

Where $F_{D,S}$ is the daylight supply factor. It is not clearly defined in the standard, but represents the contribution of daylight to the required illuminance in the zone under consideration.

$F_{D,C}$ is the daylight control factor. It represents the lighting control system’s ability to exploit the daylight supply in the zone instead of using artificial lighting.

Where a zone is non-daylit, $F_D = 1$.

The standard gives a method to determine which areas are to be classed as daylight zones, and which as non-daylight zones. Where a window or windows are located on a vertical façade, the depth of the daylight zone from that façade is calculated from a simple mathematic relationship between the height of the window head and the height of the working plane. The width of the daylight zone is described as the length of the façade, unless windows are only located in parts of the façade. In this case the width of the daylight zone is given as the width of façade section containing windows plus half the depth of the daylight zone. This can give unusual results in some situations with single luminaires at each side of the room being omitted from the daylit zone.

For rooflights EN15193 states that task areas directly underneath rooflights that are uniformly distributed across the roof surface are treated as daylight zones. For other cases (such as single rooflights) the area of a daylight zone under a rooflight is based on the difference between the height of the space and the height of the task area.

For a situation where a space is lit from more than one façade and/or rooflight, the standard suggests using the more favourable case of the superimposed daylight zone.

Anywhere in the space/room outside the calculated daylight zone is classed as a non-daylight zone and therefore should have a daylight dependency factor $F_D = 1$. The standard does not give any advice for when a luminaire may provide illuminance to areas both in a daylight and non-daylight zone.

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2.2.1 Daylight supply factor

For daylight zones, the daylight supply factor ($F_{D,S}$) is evaluated based on the daylight factor classification.

2.2.1.1 Vertical facades

For vertical facades the daylight factor is calculated via a function dependent on the transparency index I_T, depth index I_{De} and obstruction index I_O.

The transparency index I_T gives the relationship between window size and area being illuminated by daylight. It is calculated by the area of the openings in the façade (windows or rooflight), not including frames, divided by the total task area in the daylight zone.

The depth index I_{De} is the depth of the daylight zone divided by the difference between the height of the top of the window(s) and the height of the task plane.

The obstruction index I_O is a way of accounting for external obstructions reducing the amount of light to the façade. It is a product of five further factors, designed to take into account various obstruction types. These are linear obstructions, overhangs, vertical fins, courtyards/atria and glazed double facades.

The factor for a linear obstruction is based upon the obstruction angle, which is the angle from the centre of a window (carcass opening) to the top of an obstruction. Advice or methodology for more complex external obstructions is not given. In the draft 2014 revision of EN15193 (ref 16) it is specified that the angle should be measured from the external wall surface.

The factor for an overhang is based upon the angle from the centre of the window to the edge of the overhang. In the draft 2014 revision it is specified that the angle should be measured from the external wall surface.

The factor for a single vertical fin is based upon the angle from the centre of the window to the edge of the fin. In the draft 2014 revision it is specified the angle should be measured from the external wall surface. A single fin is quite an unusual building geometry; a fin either side of the window would be more common.

The factor for courtyards/atria is based on a simple mathematic model, taking into account the length, width and height of the space. Light lost due to an atrium roof is also included.

Glazed double facades are areas around a window opening, such as a conservatory. The factor takes into account the transmission factor of the glazing, frames, dirt and non-perpendicular light incident on the double façade.

If the type of obstruction is either not present, or has no effect on the amount of light the window opening can receive, then the individual factor is given a value of 1. Therefore the obstruction index I_O has a value of 1 if there is no obstruction of light to the window opening.

The standard then presents a formula for the daylight factor D_C of the daylight zone for the “carcass façade opening”. The carcass façade opening is the window opening area without frames, glazing or sun protection systems.

$$D_C = (4.13 + 20.0 \times I_T - 1.36 \times I_{De}) \times I_O \ (\%)$$

According to the draft technical report accompanying the standard (ref 17) this model of daylight factor calculation is based on using standard surface reflectances of:

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- Floor: 0.2
- Wall: 0.5
- Ceiling: 0.7
- Exterior (Ground, obstruction): 0.2

A daylight factor D which takes into account frames and glazing can be calculated by taking the product of D_C and factors for the transmission of the glazing, frames, dirt on the glazing and non-perpendicular light incident on the façade.

The standard then classifies the daylight penetration of the daylight zone using either D or D_C. There are four classification categories: strong, medium, weak and none.

Table 2.1: Daylight penetration classification from EN15193 for vertical facades

Daylight Factor		Classification
D_C	D	
D_C >= 6%	D >= 3%	Strong
6% > D_C >= 4%	3% > D >= 2%	Medium
4% > D_C >= 2%	2% > D >=1%	Weak
D_C < 2%	D < 1%	None

The daylight supply factor $F_{D,S}$ is calculated using the daylight penetration classification and the maintained illuminance (required or actual) to find two further coefficients (a, b). These coefficients are presented in the standard for maintained illuminances of 300lux, 500lux and 750lux. The coefficient values presented are valid for a daily operation of 8am till 5pm. The standard states that for longer hours the values should be multiplied by a factor of 0.7.

The daylight supply factor $F_{D,S}$ is then given by

$F_{D,S}$ = a + b x site latitude

Coefficient b is always negative, so the method predicts less daylight at high latitudes, as might be expected.

In the draft revision of EN15193 calculation of the daylight supply factor is more complex as it takes into account solar / glare protection i.e. blinds, light guiding systems or other shading devices. The revised total daylight supply factor is the daylight availability factor of the area when solar / glare protection is not activated times the portion of operating time it is not activated, plus the daylight availability factor of the area when solar / glare protection is activated times the portion of operating time it is activated.

The relative operational time a solar / glare protection system is active / not active is given in tables in the draft revision as a function of site latitude, climate and façade orientation.

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The daylight availability of an area at times when the solar / glare protection system if not active is given in tables in the draft revision as a function of site latitude, climate, daylight factor (D, taking into account frames and glazing) and maintained illuminance.

The daylight availability of an area at times when the solar / glare protection system is active is given as a function of daylight penetration classification and the type of system used.

2.2.1.2 Rooflights

For rooflights the daylight supply factor $F_{D,S}$ is determined via the daylight factor and associated daylight classification.

The standard presents a formula for the average daylight factor of a daylight zone. This is a function of external daylight factor, transmittance and scattering of the glazing material, frame factor, dirt factor, factor for non-perpendicular light, utilisation factor, area of the rooflight openings and area of the considered zone. No factor for external obstructions is included.

The external daylight factor is the illuminance on the outer surface of the rooflight in the plane of the glazing for overcast sky conditions divided by the unobstructed horizontal outdoor illuminance at overcast sky conditions. The standard presents values for the external daylight factor for various slope angles of rooflights.

The utilisation factor is a function dependent on the dimensions of the zone and rooflight(s) in question. The standard gives examples of rooflights and how the dimensions relate to each type. The utilisation factor is then determined using tables presented in the document.

In a similar way to vertical facades, daylight classification is determined based on the value of daylight factor.

Table 2.2: Daylight penetration classification from EN15193 for rooflights

Average Daylight Factor D	Classification
D >= 7%	Strong
7% > D >= 4%	Medium
4% > D >= 2%	Weak
D < 2%	None

To determine the daylight supply factor $F_{D,S}$ the classification is used with site latitude, maintained illuminance, orientation and slope angles of the rooflight. The standard provides tables for various locations where this value can be looked up. No mathematical functions are given.

Similarly to vertical facades, in the draft revision of EN15193 the calculation of the daylight supply factor for rooflights also takes into account shading devices, if they are present. This involves calculation of two average daylight factors and associated classifications, one with the shading active and one without. The

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average daylight factor is calculated as above, but with the transmission of the shading device taken into account when active.

The revised total daylight supply factor is the daylight availability factor when the shading device is not activated times the portion of operating time it is not activated, plus the daylight availability factor of the area when the shading device is activated times the portion of operating time the shading is activated.

The relative time a shading system is used / not used is dependent on site latitude, orientation and slope of the roof light. Example values are given in a table in the draft revision.

The daylight availability factor when the shading is activated / non activated depends on location, daylight classification, orientation, maintained illuminance and slope of the roof light. Example values are given in tables in the draft revision.

2.2.2 Daylight control factor

The daylight control factor $F_{D,C}$ is a way to take account of how effectively lighting controls can minimise the use of artificial lighting by using the supply of daylight. The standard presents the following table, with values dependent on control system and the classification of daylight supply.

Table 2.3: Daylight control factor $F_{D,C}$

Control of artificial lighting system	Daylight penetration classification		
	Weak	Medium	Strong
Manual	0.2	0.3	0.4
Automatic, daylight dependent	0.75	0.77	0.85

Note that there is only one set of figures for all types of automatic control. There would generally be greater savings from dimming control compared to on-off switching (see section 3), but this is not reflected in the current EN15193. Credit is given for savings from dimming lamps early in life when their output exceeds the recommended illuminance, but this does not include the extra savings from dimming lamps when daylight can supply part of the recommended illuminance.

The overall daylight dependency factor is then given by

$F_D = 1 – (F_{D,S} \text{ X } F_{D,C})$

This is then multiplied by the hours of occupation of the building during daytime, and an additional control factor to allow for building occupancy before being input into the LENI calculation.

In the draft revision of EN15193 the daylight control factor becomes more complicated, being dependent on daylight classification (although it does not specify if this is with or without shading devices activated for rooflights), maintained illuminance and type of control system, including various options for dimmed or switched systems.

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2.3 Climate based daylight modelling

Climate-based daylight modelling (ref 18) is a method to predict daylighting quantities (typically illuminance or luminance) using meteorological datasets that cover sun and sky conditions over the whole year (though sometimes the simulation may cover a shorter period such as a season or school year, and may be limited to the working day). Essentially it involves calculating the daylight in a space on an hourly basis, creating a dataset of internal illuminances and/or luminances for each hour of the year (or alternative period of interest).

A typical CBDM methodology might involve the following process (ref 1):

a. Obtain basic climate data from a weather tape, usually global and diffuse irradiance. For example, CIBSE has compiled climate datasets for 14 locations across the UK (ref 19). Derive direct (solar) irradiance from these values and the solar altitude.

b. Convert the irradiance data to external horizontal illuminances using a luminous efficacy model (ref 20).

c. Generate a sky luminance distribution using a sky model.

d. Use the sky luminance distribution to calculate internal illuminances. To avoid a full lighting simulation for each hour of the year, the daylight coefficient approach (refs 21, 22) can be used. A lighting simulation is carried out for each patch of the sky. To find the internal illuminance for a given sky luminance distribution, multiply the daylight coefficient for each patch of sky by its luminance and angular size, and then sum all these values. Prediction of sunlight illuminance may be carried out with a modified approach based on the daylight coefficients.

e. Determine the artificial lighting requirements using a lighting control algorithm.

f. Calculate the resultant heat gains produced by the lighting (if the lighting simulation is to be part of an integrated buildings energy analysis program).

The above describes a time series analysis. The data produced could be used as a basis for assessing the overall daylighting potential of the building (see below), identifying excessive illuminances or luminances, modelling human exposure to daylight and its effects on their circadian rhythms (ref 23) inputting to behavioural models for light switching and/or blinds usage, and assessing the performance of daylight linked lighting controls.

As it is not straightforward to interpret such a large amount of data (for a full year, 8760 values of illuminance or luminance for each point in the space), further post processing and aggregation is usually carried out on the data. The most common is cumulative analysis. This involves calculating the proportion of time that a given measure (e.g. total illuminance) occurs or is exceeded. It is directly related to lighting use under photoelectric (daylight linked) control, and can be used to assess how often daylight is sufficient or excessive, and to calculate the exposure of art works to light.

One of the issues with CBDM is that it tends to average out some of the largest fluctuations in daylight. Daylight and sunlight can vary considerably even within the space of an hour, and by taking an hourly average the highest and lowest values are lost. Walkenhorst et al (ref 24) have shown that this can lead to significant errors in predicting lighting use. Also partly cloudy skies, particularly with broken cloud, often have highly varying luminance distributions. Nearly all sky models are based on averages of these distributions and therefore tend to average out the brightest and dullest parts of the sky. Of course it can be argued that this is still much better than a daylight factor approach based on one single luminance distribution.

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Even when aggregated into a cumulative distribution, CBDM still results in a lot of numbers. Accordingly new metrics have been proposed which are derived using CBDM but are simpler to handle. These are daylight autonomy (section 2.4) and useful daylight illuminance (section 2.5).

2.4 Daylight autonomy

According to Reinhart et al (ref 25), the concept of Daylight Autonomy (DA) dates back at least to 1989 when it was included in a Swiss standard (ref 26). It is the percentage of the year for which a required daylight illuminance is exceeded, at a particular point on the working plane. In 2001 Reinhart and Walkenhorst (ref 27) redefined daylight autonomy as the percentage of the occupied times of the year when the minimum illuminance requirement is met by daylight alone. The required illuminance is commonly taken from electric lighting standards such as the SLL Code for Lighting (ref 28) or BS EN 12464-1 (ref 29). The percentage saving from a photoelectric switch (see section 3.2) is linked to the daylight autonomy at the point in the room where switching occurs.

Daylight could still be viewed as making some contribution even when the illuminance provided by daylight is less than the required illuminance. Rogers (ref 30) has proposed the concept of continuous daylight autonomy to cover this. In this metric, when the required illuminance is 500 lux and a point receives 300 lux of daylight, that is credited as 300/500 or 60% daylight for that time step, in summing the daylight autonomy for the whole year (daylight illuminances over 500 lux would still be credited as 100% daylit for that time step). The percentage saving from a photoelectric dimmer (see section 3.3) is linked to the continuous daylight autonomy at the point in the room where dimming occurs.

Daylight autonomy as defined above will vary with position in a room. A point at the back of a room will have low daylight autonomy while points close to the windows will have higher values. To address this, the IES of North America has introduced the concept of spatial Daylight Autonomy (sDA) (ref 31). It is defined as the percentage area of a space which meets a minimum daylight illuminance for a specified fraction of operating hours. It suggests default values of 300 lux for the minimum illuminance and 50% for the fraction of operating hours (default operating hours are taken to be 8am to 6pm local clock time). This would be written as $sDA_{300,50\%}$. It is equal to the percentage of the space that has a daylight autonomy, as defined by Reinhart and Walkenhorst (ref 27), of 50% or more for a required illuminance of 300 lux; or the percentage of the space for which 300 lux is exceeded for more than 1825 hours between 8am and 6pm over a year (10 x 365 x 50%).

The IES document gives two sets of recommendations for spatial daylight autonomy. For preferred daylight sufficiency it recommends that 75% of points analysed exceed 300 lux for more than 50% of the above time period. For ‘Nominally accepted’ daylight sufficiency it recommends that 55% of points analysed exceed 300 lux for more than 50% of this time period (ref 31).

The IES recommendations are based on a survey (PIER, ref 32) of 61 spaces (classrooms, open offices and libraries/lobbies) in the United States, which included simulation of the daylighting within the spaces as well as obtaining the views of occupants and visiting experts.

A daylight autonomy based recommendation is also given in the UK Education Funding Agency (EFA) design brief for new schools funded under the Priority Schools Building Programme (refs 33, 34). This requires a daylight autonomy of 50% for the target illumination (typically 300 lux in teaching spaces), for the hours of operation from 8.30 am to 4.00 pm. (This is understood to be for 50% of the working plane). The working year covers weekends and school holidays as well as weekdays during term time.

As part of the project, a workshop was held in London on 12 February 2015 for consultants involved in daylight design of schools to meet the EFA criteria. The daylight autonomy criterion was seen as

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relatively easy to achieve (compared to the Useful Daylight Illuminance criterion also required by the EFA, see next sub-section). Using daylight autonomy means that design solutions might have to vary in different parts of the country because of different levels of outdoor daylight. Also, the complex calculations involved in evaluating daylight autonomy might not be cost effective for smaller school projects involving construction of one or two extra classrooms.

A similar, but subtly different recommendation is under consideration for a forthcoming European standard on daylighting (refs 35, 36). It recommends that, to be considered daylit, a workroom should have at least 300 lux at 50% of the points within the room for at least half of the daylight hours during the year. If the daylight in the workroom is predominantly from roof lights then 90% of the points should meet this criterion. There is similar guidance for classrooms and nurseries.

In dwellings, the recommendation is the same, but there is an additional recommendation that none of the grid points in the room should receive less than 100 lux of daylight for more than half of the daylit hours in the year.

Half of the daylight hours is a total of 2190 hours throughout the year. This makes the draft European recommendation significantly stricter than the EFA UK schools recommendation. The EFA recommendation of 50% of daylight autonomy over an 0830-1600 day means that 300 lux has to be exceeded for only 1369 hours of the year.

In London (Kew) an external diffuse illuminance of 13300 lux is exceeded for more than half of daylit hours (analysis based on data from reference 37). Over an 0830-1600 day, 17800 lux is exceeded more than half the time. Assuming proportionality of internal to external illuminance, the EFA recommendation, of 300 lux being exceeded for half an 0830-1600 working year, is equivalent to only 300 x 13300 / 17800 = 224 lux being exceeded for half of daylit hours. The IES ‘nominally acceptable’ recommendation is in between the two, although it covers a slightly larger fraction of the working plane.

The 300 lux illuminance threshold appears to have been developed from consideration of recommended illuminances in offices and schools. The PIER survey study (ref 32) which provided the data on which the IESNA spatial Daylight Autonomy metric is based, was limited to these types of building together with public libraries. It is unclear to what extent a 300 lux based Daylight Autonomy metric is applicable to interiors with markedly different recommended illuminances, for example dwellings where 100 lux is often viewed as sufficient, or retail stores where 1000 lux of electric lighting may be common.

The latest BREEAM criteria for daylight (ref 5) contain an alternative calculation method which is a type of daylight autonomy calculation. This is based on the number of hours per year for which a given average illuminance in the space (averaged over the whole working plane) is exceeded. Additional criteria require the minimum daylight illuminance to be above a set value for a certain number of hours of the year. The set illuminance values do vary with the type of space.

For general spaces including offices, factories, education buildings, and public areas of hospitals, 300 lux average illuminance should be exceeded for 2000 hours of the year, and 90 lux minimum illuminance exceeded for 2000 hours. For hospital wards and consulting rooms, 300 lux average illuminance should be exceeded for 2650 hours, and 90 lux minimum illuminance exceeded for 2650 hours.

For kitchens and living rooms in multi-residential buildings, 100 lux average illuminance should be exceeded for 3450 hours, and 30 lux minimum illuminance exceeded for 2000 hours. For communal rooms in multi-residential, 200 lux average illuminance should be exceeded for 2650 hours, and 60 lux minimum illuminance exceeded for 2650 hours. In prison cells the criterion is for 100 lux average illuminance to be exceeded for 3150 hours (there is no minimum illuminance criterion).

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For retail sales areas, the criterion is closer to a conventional daylight autonomy formulation. It is that 200 lux point illuminance should be exceeded for 2650 hours, for at least 35% of the sales area.

These recommendations are based on the existing average daylight factor based recommendations in BREEAM. The standard BREEAM criterion for general spaces, including offices, factories, education buildings, and public areas of hospitals, is to have 2% average daylight factor. For an internal illuminance of 300 lux, this corresponds to an external illuminance of 300 x 100 /2 = 15000 lux.

According to data in the BRE Report 'Availability of daylight' (ref 37) this is exceeded for 22.4% of the whole year or 1962 hours. This was rounded up to 2000 hours for the BREEAM criterion. Hence the general recommendation for 300 lux to be exceeded for 2000 hours of the year.

The above analysis ignores the extra light from sunlight which could be included in a full climate based analysis. This means that using the illuminance criteria, in conjunction with such an analysis, ought to give more favourable results, especially for south facing windows.

2.5 Useful daylight illuminance

In 2005 Mardaljevic and Nabil (refs 38, 39) proposed a new metric that builds on the daylight autonomy concept. This is Useful Daylight Illuminance (UDI). It is based on the idea that providing too high a daylight illuminance may be as bad as providing too low a level, since very high daylight illuminances can lead to glare, and then occupants may use shading devices to shut out the light. Thus the Useful Daylight Illuminance represents the operating hours during which the daylight illuminance falls within a 'useful' range (initially 100-2000 lux was proposed (refs 25, 38)).

Note that despite its title UDI is not expressed in units of lux but as either a percentage of annual operating hours (ref 25), or a number of hours (ref 40).

In a more sophisticated form (ref 40), UDI is composed of five different metrics, each describing the operating hours during which the illuminance E is in a particular range:

- UDI-f (UDI 'fell-short') E <100 lux
- UDI-s (UDI supplementary) 100 lux < E < 300 lux
- UDI-a (UDI autonomous) 300 lux < E < 3,000 lux.
- UDI-c (UDI combined) 100 lux < E < 3,000 lux.
- UDI-e (UDI exceeded) E > 3,000 lux.

UDI-a could be viewed as the 'ideal' range for daylight illuminance. UDI-s could be viewed as the range where daylight makes some, but not a full, contribution. UDI-c is the sum of UDI-a and UDI-s. UDI-f can be thought of as the range when daylight illuminances are too low, and UDI-e when daylight illuminances are too high.

The UK Education Funding Agency design brief for new schools funded under the Priority Schools Building Programme (refs 33, 34) gives a UDI based recommendation (as well as the daylight autonomy recommendation described in section 2.4). This is that UDI-a (100 Lux – 3000 Lux) will be achieved for an average of 80% of the time (an 0830-1600 hours year) over the working plane within a space. The individual UDIs are averaged over the working plane. So the procedure is: for every point on the working plane, calculate the proportion of the school hours year its illuminance is between 100 and 3000 lux. The

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average of all these proportions should be at least 80%. The area boundary of 500mm from walls may be excluded from the calculation unless it is known that the task area will be around the perimeter, e.g. in some science classrooms (ref 34).

At the workshop for daylight consultants who used UDI in the design of schools for the Education Funding Agency (EFA), the following views were expressed about UDI:

a) In general, the UDI criterion was more difficult to achieve than the daylight autonomy criterion, also in the EFA guidance (see section 2.4 above).

b) UDI encouraged designs which had limited window areas but better uniformity, either by the use of high ceilings and window heads, or by using rooflights, or by using windows in more than one side of the room.

c) Conventional daylight criteria such as average daylight factor encouraged designers to have windows as large as possible, and shading was an afterthought. UDI encouraged them to think about shading from the outset.

d) Different consultants had different approaches to modelling shading. As UDI was originally conceived, the intention was that the required UDI be met using passive means with fixed shading. Some consultants aimed for this approach but assumed a particular position for moveable blinds. Others used more complex algorithms for blind use, assuming that users would lower blinds on excessively bright days. This second approach would make it easier for spaces to comply, but in practice users might not adjust the blinds in the ways they were supposed to. A particular issue for the EFA programme was that the funding available was unlikely to pay for complex architectural solutions like light shelves or prismatic glazing.

e) Comparative tests of different software had given similar results. However UDI did depend on the weather file used; some locations were sunnier than others and that made for a larger UDI-e. Accurate and reliable weather data were essential.

f) The EFA guidance currently required a 5 minute time step for modelling, which generated a lot of data. As weather data were only available as hourly values, intermediate daylight calculations were generated by interpolation. This made the use of a short time step of questionable benefit. An exercise had shown that a 15 minute time step gave similar results to a 5 minute step. However a longer time step could lead to situations where sun penetration to a particular area was ‘missed’. This could result in the UDI being overestimated.

g) Grid size was also a key issue. The EFA guidance currently required a 250mm grid size, which resulted in a lot of calculation points especially in large spaces like halls and gymnasia. For most spaces, especially where windows go right down to the working plane, having a bigger grid might make it easier to achieve a particular average UDI, because there would be fewer points very close to the windows (and hence exposed to high illuminances) and fewer points very close to the rear walls and corners of the room. With some window patterns, a larger grid could also result in grid points aligning with the windows, providing an unreliable assessment of the room as a whole. Using an offset, where points within a set distance of the walls are omitted from the calculation, will have a similar (and possibly more pronounced) effect. The EFA guidance allows a 0.5m offset except in rooms like science labs which are designed to have benching around the walls.

UDI is based on the idea that high illuminances on the working plane are linked to glare and use of shading devices. Sunlight is the most severe source of glare (ref 41) and direct sunlight entering a space is normally linked to high internal illuminances on parts of the working plane. This may not necessarily be in the location where somebody is working; since people sit with their eyes above the working plane, the

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illuminance on their desk may be below 3000 lux even if the sun is shining in their eyes or on their computer screen. However in this situation it is likely that the working plane illuminance in some other location is above 3000 lux, as the sunlight is likely to strike the working plane somewhere.

At high solar altitudes, or in interiors with overhangs or interior light shelves, sunlight can enter a room and only reach the parts of the working plane very close to the window. This situation is likely to cause less glare as the sun will not be shining in people's eyes or on computer screens, but it could still affect the UDI if the sun reaches more than 500mm from the window wall.

Close to the windows, there can be situations on bright days when diffuse illuminances could exceed 3000lux even in the absence of direct sunlight. This could lead to uncomfortable contrasts between bright pieces of paper on a desk, or a light coloured keyboard, and a darker computer screen. It can also lead to computer screens being 'washed out' by a veil of reflected daylight. However, developments in computer technology, with low reflectance, positive polarity (black letters on white background) screens (ref 42), reduce these effects and make computers easier to use with high levels of ambient light.

The EFA daylight design guide (ref 33) states that 'There is some debate about the best range to use for UDI as daylight can be useful up to as high as 5000 lux depending on the activities taking place. Where the lighting designer believes the upper limit should be higher and will not introduce discomfort or disability glare then this can be raised.'

The PIER study of 61 office, classroom and library/lobby areas in the United States (ref 32) concluded that 'No level of annual daylight illuminance was found to be 'too high', i.e. to predict occupant discomfort. Indeed, low levels of daylight illuminance were found to most strongly predict occupant discomfort relative to contrast, reflections or glare. Given these findings, the committee elected not to recommend an upper limit to daylight illuminance'.

This finding could have been partly at least due to the methodology in the study. The expert surveys took place in July and August when the sun was at a high altitude (most of the buildings were in California). Under these circumstances glare from low angle sun was less likely. The highest illuminances were often in spaces with diffusing skylights, which would have caused less glare than sun through side windows. Also most of the spaces had blinds that the occupants could control. Two of the modelling options either involved closed blinds or blinds that were automatically used when working plane sunlight illuminances exceeded a set value. These options would have excluded the highest illuminances. However it appears from the report that even for a third modelling option, blinds open all the time, high illuminances did not predict occupant discomfort.

Subjective studies of daylighting in offices by Roche et al (refs 43, 44) are also relevant to the UDI approach, although they predated UDI and did not calculate it directly. Occupants of 16 UK office buildings were questioned about their satisfaction with daylight in their buildings. In offices with average daylight factors over 5%, people were more likely to be dissatisfied with their daylight than those in offices with lower average daylight factors. They were more likely to report glare from the sky and sun.

Paradoxically, they were more likely to report that there was too little daylight rather than too much, but this was probably because blinds would have been lowered to control glare. These results therefore indicate that it is not so much the high illuminances themselves that cause the problem, but that interiors with such high illuminances are often associated with glare and lowering of blinds.

The debate around UDI has been focused on offices and schools. Glare is a particular problem in these building types for two reasons. Office workers and school students are more likely to be carrying out exacting visual tasks including work on computer screens. Also, they are more likely to have fixed working locations, so if sunlight is entering one part of the space it is difficult for them to move to another desk. For interiors where glare is less of an issue, and where people can move around to avoid it, UDI is

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less relevant. For example in homes sunlight is generally welcome (ref 45). In these situations daylight autonomy would be a more relevant climate based metric than UDI.

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3 Calculating electric lighting use in daylit interiors

3.1 General approach

Providing daylight in a building does not by itself lead to energy efficiency. Appropriate lighting controls are required to ensure that lighting is switched off when daylight is sufficient. The electric lighting use therefore depends on the type of control and the way it works as well as daylight provision within the space.

The calculation usually comprises four stages (ref 46):

(i) Obtain suitable external daylight illuminance data. These can be directly measured (Hunt (ref 37) gives data for the UK) or calculated from radiation data. Alternatively daylight data may be available on weather tapes.

(ii) Calculate a profile of internal daylight illuminances for the point or area where the control will operate. This can be done in various ways.

(iii) Use the internal daylight data, and a knowledge of lighting control operation, to determine whether lighting is in use and whether it is dimmed.

(iv) Calculate the resulting lighting energy consumption by multiplying by full lighting power loading and the number of hours it is used for.

For most basic energy applications the key quantity is the total lighting use over the year. This makes it possible to use simplified approaches to calculate lighting use (see below).

However, electric lighting contributes to the energy use in a building in two ways:

(a) as an energy consumer in its own right;

(b) as a casual gain affecting the heat balance of the building. Casual gains generally reduce the demand for heating, and increase the demand for cooling and mechanical ventilation if these systems are present in the building.

To properly model the effects of lighting as a casual gain, the dynamic simulation of variations in lighting use on an hourly basis is required. Casual gains are only useful at certain times of day and year. During the summer a combination of solar gain and casual gain can tip the balance towards overheating unless lights can be switched off in response to daylight. A good dynamic simulation should be able to analyse this sort of situation. The problem then becomes one of producing a load profile of the heat gain from electric lighting as daylight conditions change and lighting is switched on or off. This adds a fifth stage to the calculation; the lighting energy consumption is multiplied by a factor to determine the proportion of the lighting energy consumed that is retained within the building or zone (for most types of lighting, this factor is taken as 1) and the resulting energy is input to the thermal calculation for the building or zone.

3.2 Photoelectric switching

In its simplest form the on/off control switches off the lights when a particular daylight illuminance is reached at the control point, and switches them on again when the daylight illuminance drops below this control value. This is the easiest type of lighting control to model. An on/off photoelectric control will

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switch the lights off if the illuminance is above a particular switching illuminance E_s. The fraction of time the lights will be off is given by the fraction of operating hours E_s is exceeded. This is equal to the daylight autonomy at the point at which the switching illuminance is sampled.

In a room which is all switched using one control, this point ought to be at the back of the room, in the worst lit place where people are working. Thus the illuminance would be the minimum daylight illuminance in the space (this may not be in the exact corner of the room, usually a 0.5m or 1m leeway is given because nobody works right in the corner). In a room where each row of lights is controlled separately, or there is a non daylit area at the rear of the space where lighting is left on continuously, the situation is more complex as the adjoining row of lights will provide some light. This extra spill light could be subtracted from the switching illuminance so that in this situation E_s would be less than the required illuminance. Thus if the required illuminance was 500 lux, and the row of lights behind would provide 100 lux at the sampling point, the switching illuminance would be 400 lux. Of course all this depends on whether the photoelectric control is calibrated correctly.

Lynes and Littlefair (ref 47) give a way to estimate savings in interiors where the location of luminaires and control points has yet to be decided. This is based on dividing the interior into two zones.

Hourly simulation in a dynamic computer program is straightforward. If the hourly average illuminance at the control point is above E_s then the lighting is assumed to be switched off for the entire hour. Otherwise it is assumed to be switched on. The use of hourly averages does not cause large errors here because the cumulative distribution of hourly average illuminances is fairly close to the cumulative distribution of instantaneous illuminances (ref 48). The main exception to this occurs at very high daylight illuminances; if the photoelectric control savings are very low they will be underestimated by an hourly simulation.

There are various methods to calculate savings from photoelectric control using daylight factors (ref 46). The simplest is to divide the switching illuminance by the daylight factor to get the external illuminance at which switching occurs. The relative saving is then taken to be the proportion of the working year this illuminance is exceeded.

This method tends to underestimate the savings in south facing rooms. Orientation factors (ref 46) have been proposed to take account of this. This is the method suggested in the British Standard on daylight, BS 8206 Part 2 (ref 1). An alternative approach is to use vertical illuminance data as the basis for the calculation (ref 49).

A special problem with the photoelectric switch is the rapid switching of lights on and off on occasions when daylight levels are fluctuating around the switching illuminance. This can annoy occupants and reduce lamp life. Various techniques have been developed to reduce the number of switch offs (ref 50).

The differential switching strategy has been used for many years in street lighting. Unlike the standard photoelectric switch, the differential control has two switching illuminances; one (E_{off}) at which the lights are switched off, and another, lower, illuminance (E_{on}) at which the lights are switched on. This reduces rapid switching on and off of the lights and also makes switching off less obtrusive, as it is performed when daylight represents a higher proportion of the illuminance to which the eye is adapted. Empirical analysis (ref 45) shows that the relative energy saving is close to the fraction of hours E_{mean} is exceeded, where E_{mean} is the average of the two switching illuminances E_{off} and E_{on}. This is the daylight autonomy at the switching point for an illuminance of E_{mean}.

Another way to reduce the frequency of switching operations is to introduce a time delay. This could be:

(I) a switching linked time delay where switching off cannot occur until at least n minutes after the last switch on, where n is a preset delay;

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(ii) a daylight linked time delay where switching off cannot occur until the daylight illuminance has exceeded the target value E_s for n minutes.

Delay in switching on is undesirable because that could lead to illuminances falling well below desired levels.

Of the two different control strategies, a daylight linked time delay (waiting for the daylight illuminance to exceed the target value for n minutes) gives significantly less switching (ref 50). Even quite a short time delay gives a significant reduction in switching. The energy consumption for a switch with time delay will be greater than for an instantaneous on/off switch. This is because there will be times when daylight exceeds the switching illuminance but the lighting is still left on because the time delay has not elapsed. There is no simple mathematical way to calculate the effects of this. However it is possible to compensate empirically for the effects of time delay, by using a higher switching illuminance. Reference 50 gives equations for this.

3.3 Photoelectric dimming

Photoelectric dimming allows smoother and less noticeable control than photoelectric switching, and potentially greater energy savings. If the daylight illuminance E_x is greater than the required illuminance E_s then the lights will be switched off, or dimmed to a low level. However if E_x is less than E_s the control will, in principle at least, top up the illuminance to E_s by making the artificial lighting provide an extra illuminance $E_s - E_x$. In this case the fractional power saving from an ideally efficient control is given by E_x/E_s. This fraction can be used directly in hourly simulations. Over a whole year, the saving from an ideally efficient dimming control approximates to Rogers' continuous daylight autonomy (ref 30), which gives partial credits to small amounts of daylight (see section 2.4 above).

Real photoelectric dimmers do not behave in the same way as the 'ideal' dimmer described above. In the older type of mains frequency control, the power consumed in the ballast is roughly proportional to the lamp output, but the consumption of the cathode heaters is a constant whenever the lamp is not completely switched off (ref 51). This is typically around 12% of the power consumption of the undimmed lamp and ballast (ref 52).

Nowadays, high frequency dimming control is much more common. This uses electronic circuitry which is around 20% more efficient than conventional ballasts. The lamps cannot be dimmed smoothly to total extinction. Their minimum light output is R_f times the full value; the corresponding fractional power consumption is R_w. Typical values of R_f and R_w are 0.125 and 0.33 respectively for the longer established form of dimmer, with lower values for more recent and sophisticated types (ref 53). In normal operation their residual light output and power consumption will occur throughout working hours even if the daylight illuminance exceeds the target value E_s; unless the circuit is switched off by the occupants, an occupancy sensor or time switch. For this reason high frequency dimming may give poorer savings than on/off switching in very well daylit spaces when the illuminances nearly always exceed E_s (ref 54).

Whenever the total illuminance (daylight plus electric light) exceeds the target value E_s, the fractional power consumed will equal R_w and the fractional saving will be $1-R_w$. This occurs when the daylight illuminance exceeds E' where $E' = E_s (1 - R_f)$. The remaining light is provided by the maximally dimmed luminaires. When the daylight illuminance E_x is less than E', the savings are given by

Fractional energy saving = $E_x/E_s \times (1-R_w)/(1-R_f)$

These expressions can be used in an hourly dynamic simulation by substituting the hourly average illuminances for E_x.

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It is possible to calculate savings from photoelectric dimming using daylight factors (ref 53). The first step is to divide the switching illuminance by the daylight factor and an orientation factor to get the external illuminance at which the required internal illuminance occurs. The relative saving is then related to the proportion of the working year this illuminance is exceeded, plus the savings from the proportions of the year when lower external illuminances occur. Reference 55 gives curves for the London area which can be used to calculate this.

The above analysis covers daylight related savings alone and does not include any maintenance related savings, where the lamps can be dimmed early in their life when the illuminance provided by them exceeds the required maintained illuminances (ref 55). It also may underestimate the savings available from dimming LEDs; LEDs typically run more efficiently under dimming as their luminous efficacy tends to increase when they run cooler. The extent of this effect will depend on the detailed design of the LED luminaire and its heat sink as well as the type of LED lamp itself.

3.4 Manual control

Savings from manual control can be estimated using the method derived by Hunt (ref 56). In the 1970's Hunt and his BRE colleagues carried out a series of experiments to determine lighting use in manually switched installations. The main conclusions (ref 13) were as follows:

(I) In each room usually all or none of the lighting was in use.

(ii) When they entered an empty room people would decide whether to switch the lights on. Once on the lights were rarely switched off until the space became completely empty again.

(iii) The probability of people switching the lights on was most closely related to the minimum daylight illuminance on the working plane.

From these conclusions and the experimental data Hunt worked out a method for estimating the hours of lighting used by a manually switched installation (ref 56). First the probable occupancy of the room is determined; in particular, the times of day when the first person enters the room and when the last person leaves. From the minimum daylight factor in the room the probability that the first person will switch on the lights can be found, using curves provided by Hunt. The hours of lighting used are then calculated by assuming that the lights will then be left on or off until the last person leaves.

Adapting Hunt's approach for dynamic modelling of manual switching is not straightforward, but can be done (ref 53). It involves calculating the minimum workplane illuminance at the time of day when people enter the space. The switching probability p is then calculated using Hunt's empirical formula (ref 56), together with a correction factor (ref 53) to allow for Hunt's original, relatively crude method of calculating the minimum illuminances.

To simulate the apparently random element of occupant switching a random number r between zero and one is then generated. If p is greater than r all the lights in the room are assumed to be switched on and left on until the occupancy period ends, or until a time switch turns the lights off. If p is less than r, the lights are assumed to be left off until an hour when the daylight level drops below what it was at the start of the occupancy period. Then a new probability p is calculated. If this new value of p is greater than the original random number r the lights are switched on. Otherwise this process is repeated each hour that the illuminance drops. This is intended to simulate late afternoon switching.

Hunt's switching correlation was derived from data from medium sized, multi-person rooms equipped with a single switch panel. In practice the above procedure can be used for cellular offices provided

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reasonable assumptions are made about occupancy. However, for spaces with distributed local manual switching or a large task lighting element there are more problems (ref 53).

Various factors can affect manual switching which the correlations above do not take into account. If the lighting buzzes, flickers or is glaring, people will want to switch it on less. The type of task is a factor; for example display screen equipment users may require less lighting. Preadaptation, for example before entering a room from a bright atrium or gloomy corridor, may influence switching (ref 57).

3.5 Combinations of control types

Many lighting control systems now include a combination of control types, and in many situations this is recommended (ref 55). In particular systems often involve a combination of automatic control (to save energy) and manual control (to meet occupant needs and preferences). Typical combinations in daylit spaces are:

a) Photoelectric switching or dimming with manual override

b) Photoelectric switching or dimming where switching on is always done manually (this can give significant energy savings and improved occupant satisfaction compared to pure photoelectric control)

c) Manual control with a timed switch off or dim out, usually at lunchtime or at the end of the working day. Occupants can reset the lighting back on after it goes off.

d) Solar reset. This is similar to the above but the lighting only goes off if a photoelectric sensor registers sufficient daylight.

e) Full presence detection coupled with photoelectric control or any of a-d above. Presence detection on its own is not linked to daylight, and can waste energy in daylit spaces.

f) Absence detection. Switching on is done manually, but an occupancy sensor switches the lighting off. This can give good savings in daylit, intermittently occupied spaces, as people may decide they do not need the lighting on when they enter the space.

These control types can be simulated using dynamic modelling if the status of the lamps is monitored and reviewed whenever a switching operation can take place (ref 53). Hourly modelling may underestimate savings from some of these controls, for example photoelectric control with manual switch off. A short period of high illuminance may trigger a switch off and a fresh occupant switching decision, even if the hourly average illuminance remains below the required level.

For most of these control types, estimating savings using daylight factors coupled with yearly daylight data is difficult, although some suggestions are given in reference 53.

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4 Modelling daylight in example rooms

Detailed computer modelling of daylight was carried out to calculate daylight factors for a range of example rooms using two widely used computer programs: Dialux (version 4.12) and Radiance (under Ecotect Analysis 2011). Dialux and Radiance use two of the most common simulation methods applied in computer modelling to calculate and render the physical characteristics of light: radiosity and ray-tracing, respectively.

Radiosity is an application of the finite element method in which the surfaces of the modelled space are divided into a mesh of smaller patches. The method assumes that these patches are perfectly diffusing surfaces, with a constant luminance for any viewing direction. A part of the light emitted by a light source present in the scene is absorbed by each patch, whilst the rest is reflected back into the space towards other patches. This process repeats until the entire light flux, iteratively reflected, is absorbed by the surfaces of the space. View factors are calculated for each pair of patches, and the total amount of light incident on a patch is determined by summing the contribution of all patches and light sources that are visible from that patch. Although radiosity has inherent limitations in modelling surfaces that are not perfectly diffusing, particularly specular reflection, it can still provide acceptable results when evaluating scenes of relatively low complexity under simple sky conditions (as is the case of the CIE standard overcast sky which is used by Dialux for daylight factor calculations).

Ray-tracing uses a different methodology to calculate the distribution of light rays emitted in a scene, either from a light source (forward ray-tracing) or a point (backward ray-tracing). Each ray of light is associated a weight that depends on its luminous intensity. When hitting a surface in the scene, new rays are generated and their weights are proportional to the reflection properties of the surface. When a weight falls below a defined value, that ray is considered to be fully absorbed and the process is repeated for another ray of emitted or reflected light that matters in the scene. Ray-tracing can render complex geometries and materials, including specular reflection and refraction. Although a time consuming process is required to assess the emission of light rays in the different directions, backward ray-tracing reduces the processing time by only considering the light rays that reach the calculation point. The Radiance calculation engine employs backward ray-tracing.

4.1 Method used

Computer modelling of daylight was carried out for side-lit and top-lit rooms with realistic obstructions and a range of glazed areas. A large and a small room were chosen, of typical sizes. For both cases, room geometry was set to comply with daylight uniformity recommendations as per BS 8206-2:2008 so that less than 20% of the working plane lies behind the no-sky line. Room depths meet the criterion D/W + D/HW ≤ 2/(1-Rb), where D = room depth; W = room width; HW = window head height from floor level; Rb = average reflectance of surfaces in room rear half. The example rooms used in the calculations, illustrated in Figures A.1 and A.2 in Appendix A, had the following characteristics:

- Large room D x W x H = 8m x 20m x 3m
- Small room D x W x H = 4m x 3m x 2.8m
- Surface reflectances (floor / walls / ceiling) 0.2 / 0.5 / 0.7 (to match default values in EN15193)
- Side-lit rooms: window sill height 1m; window head height 0.2m below ceiling

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- Top-lit rooms: flat roof mounted rooflights of the type shown in Figure 4.1, with $h_s = 0$ and $\gamma = 90°$

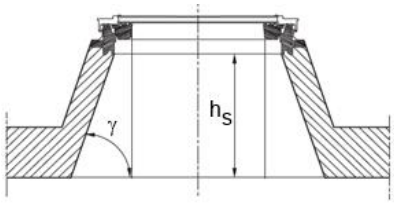


Figure 4.1 Section of rooflight type used in top-lit example rooms.

No external obstructions were considered for the top-lit rooms. Six scenarios of external obstruction, also shown in Figures A.1 and A.2 in Appendix A, were considered for the side-lit rooms in order to match the daylight supply evaluation method introduced by EN15193 (ref 15). These scenarios are as follows:

1. No obstruction. The ground was the only external element considered.
2. Linear obstruction. A linear obstruction was placed 20m away from the window wall; the height of the linear obstruction was calculated so that the no-sky line criterion in BS 8206-2 (ref 1) was met: 9.05m for the large room and 13.85m for the small room.
3. Overhang. A 0.8m deep overhang was placed externally along the entire window wall width.
4. Vertical fin. A 0.8m deep vertical fin was placed on one side of the window, along the entire room height.
5. Courtyard. The room was placed inside a 20m deep and 30m wide courtyard; the height of the courtyard was calculated so that the no-sky line criterion in BS 8206-2 was met: 8m for the large room and 12m for the small room (The room was on the ground floor).
6. Atrium. As courtyard, plus an atrium glazed roof; double glazed, solar protection glazing with visible light transmittance 0.59, framing factor 0.85, maintenance (pollution) factor 0.80 and correction factor for non-normal light rays 0.85.

There is a potential issue with the daylight calculation method in EN15193 (ref 15) which arises where a room has multiple obstructions. It recommends multiplying together all the correction factors to get the shading effect, but this approach is incorrect in two cases. First, the overhang and linear obstruction corrections are additive, as they affect different parts of the sky. Secondly, the internal courtyard factor obstructs the same parts of the sky as a linear obstruction. So the user should just take the greater of these two factors, not multiply them together.

For the side-lit rooms, the size of the windows was chosen in order to meet the BS 8206-2:2008 (ref 1) criterion regarding the minimum glazed areas for view out when windows are restricted to one wall. For each scenario of external obstruction, the window was kept centred in the middle of the wall with its height constant, and its area was increased in 5% increments (relative to wall area) from a minimum that allowed the rooms to meet the BS 8206-2:2008 view out criterion (25% of wall area in the large room; 20% of wall area in the small room) to the maximum possible area allowed by the width of the room. Eight scenes were generated by using this method. The height of the window was kept constant at 1.8m for the large room and 1.6m for the small room, and Tables A.1 and A.2 in Appendix A show the width of the window chosen in each of the eight scenes for the large room and the small room, respectively. The properties of the glazing were kept similar in all cases, as follows:

- Double glazed, direct visible light transmittance 0.82

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- Framing factor 0.85
- Maintenance factor 0.80 (called pollution factor in Dialux)
- Correction factor for non-normal light rays 0.85

For the top-lit rooms, single rooflights were installed in the centre of the rooms with a constant width. The length was increased in steps along the width of the rooms so that the rooflight area increased in 2% increments (relative to the ceiling area) from a minimum of 2% to a maximum of 16% of the ceiling area. Eight scenes were generated by using this method. The width of the rooflight was kept constant at 2m for the large room and 0.5m for the small room, and Tables A.3 and A.4 in Appendix A show the length of the rooflight chosen in each of the eight scenes for the large room and the small room, respectively. The properties of the glazing were kept similar in all cases, as follows:

- Double glazed, direct visible light transmittance 0.64
- Framing factor 0.80
- Maintenance factor 0.80 (called pollution factor in Dialux)
- Correction factor for non-normal light rays 0.85

Both in Dialux and Radiance, the average daylight factor was calculated in each scene over the entire working plane and over the daylit area only as defined by EN15193. For the small rooms, the daylit area coincided with the entire space in each scene. The average daylight factor in each example room was also calculated using the ADF formula described in Section 2.1. For the side-lit rooms, the angle of visible sky was calculated from the centre of the window in a vertical section through the window, whereas for the top-lit rooms an angle of visible sky of 180° was considered from the centre of the rooflight. The daylight factor was also calculated using the method described in EN15193. This was done both using the energy evaluation module implemented in Dialux, and an Excel spreadsheet developed by the authors, which included all the equations in EN15193.

Each room was modelled with the working plane grid at 0.8m above the floor level and with no offset distances from the walls. For all scenarios, the reflectance of all external elements was chosen to be 0.2. The correction factor for non-normal light rays was considered using the default values indicated in EN15193 (ref 15).

4.2 Large rooms

The calculation results for the large rooms are graphically illustrated in Figure 4.2 and shown in detail in Tables A.1 and A.3 in Appendix A. Following the method described in EN15193, the large rooms are divided into a daylit area and a non-daylit area. EN15193 calculates the daylight factor in the daylit area only. Therefore, the Dialux and Radiance computer models were adapted to calculate the daylight factor accordingly. Table A.5 in Appendix A shows the relative differences between the daylight factor values calculated by Dialux and Radiance computer modelling and those calculated in Excel and Dialux using the EN15193 method.

As can be seen from the results, for the side-lit rooms the daylight factor values calculated using the EN15193 method in Excel were in general the same as those calculated by Dialux using the same method. However, for the top-lit rooms the daylight factor calculated using the EN15193 method in Excel was 8% higher on average than that calculated by Dialux using the same method. Whilst the same behaviour was observed for the daylight factor for the opening (without taking into account the fenestration) and the internal equations used by Dialux could not be verified, it is believed that these differences were due to a different interpretation of the daylit area. It may be that Dialux might have

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considered a larger daylit area, in which case the depth index was higher and thus the daylight factor for the opening was lower. Nevertheless, as can be seen in Section 5, these differences did not cause significant variations in the LENI values calculated by Dialux and in Excel, which were in general the same for all the scenarios and scenes of large room. A number of differences still occurred and these are discussed in Section 5.

Whilst the daylight factors calculated by Dialux and Radiance using their built-in algorithms were slightly different (Radiance values were 10% higher on average than Dialux values for the side-lit rooms, and 8% higher for the top-lit rooms), it can be clearly seen that these values were the highest in all cases. Significant differences can be observed between the daylight factors in the daylit area calculated by Dialux and Radiance and those calculated using the EN15193 method for the side-lit rooms. The lowest difference was in the case of the side-lit room with overhang, when the daylight factor calculated by Dialux in the daylit area was 62% higher on average than that calculated using the EN15193 method. The highest difference was for the side-lit room placed in an atrium, when the daylight factor calculated by Radiance in the daylit area was 184% higher on average than that calculated using the EN15193 method. The EN 15193 method appears to overestimate the impact of the courtyard and atrium. Overall for all the side-lit rooms, the daylight factors calculated by Dialux and Radiance using their built-in algorithms were 77% and 96% higher on average, respectively, than those calculated using the EN15193 method. The differences were significantly lower in case of the top-lit rooms: on average, the daylight factors in the daylit area calculated by Dialux and Radiance were 4% lower and 4% higher, respectively, than those calculated using the EN15193 method in Excel, and 4% and 12% higher, respectively, than those calculated using the EN15193 method in Dialux.

In general for the side-lit rooms, although the daylight factors defined in EN15193 apply to the daylit areas only, their calculated values were on average much closer to those of the daylight factors calculated using the other methods (Dialux, Radiance and ADF formula) for the entire rooms. Overall, the daylight factors calculated by Dialux and Radiance using their built-in algorithms over the entire rooms were 3% and 25% higher on average, respectively, than those calculated using the EN15193 method in the daylit areas only; the daylight factors calculated using the ADF formula (over the entire rooms) were on average 19% lower than those calculated using the EN15193 method in the daylit areas only.

At first sight, these results might imply that the EN15193 method could lead to an underestimation of the daylight supply in the side-lit rooms, for any type of external obstruction, and that this might in turn generate an overestimation of the LENI values. However this would be an over-simplification. Energy savings from lighting controls are not simply related to the average daylight factor. Instead, the savings from switching or dimming each row of luminaires are more closely related to the minimum daylight factor in the area lit by that row. A lower daylight factor may therefore be more appropriate. Further work is required in this area.

For the top-lit rooms, the daylight factors calculated using the EN15193 method did not depart significantly from those calculated by Dialux and Radiance over the daylit areas. Based on the analysis above, this might end up in their overestimating the minimum daylight factors under each row of luminaires, which are more closely related to lighting use.

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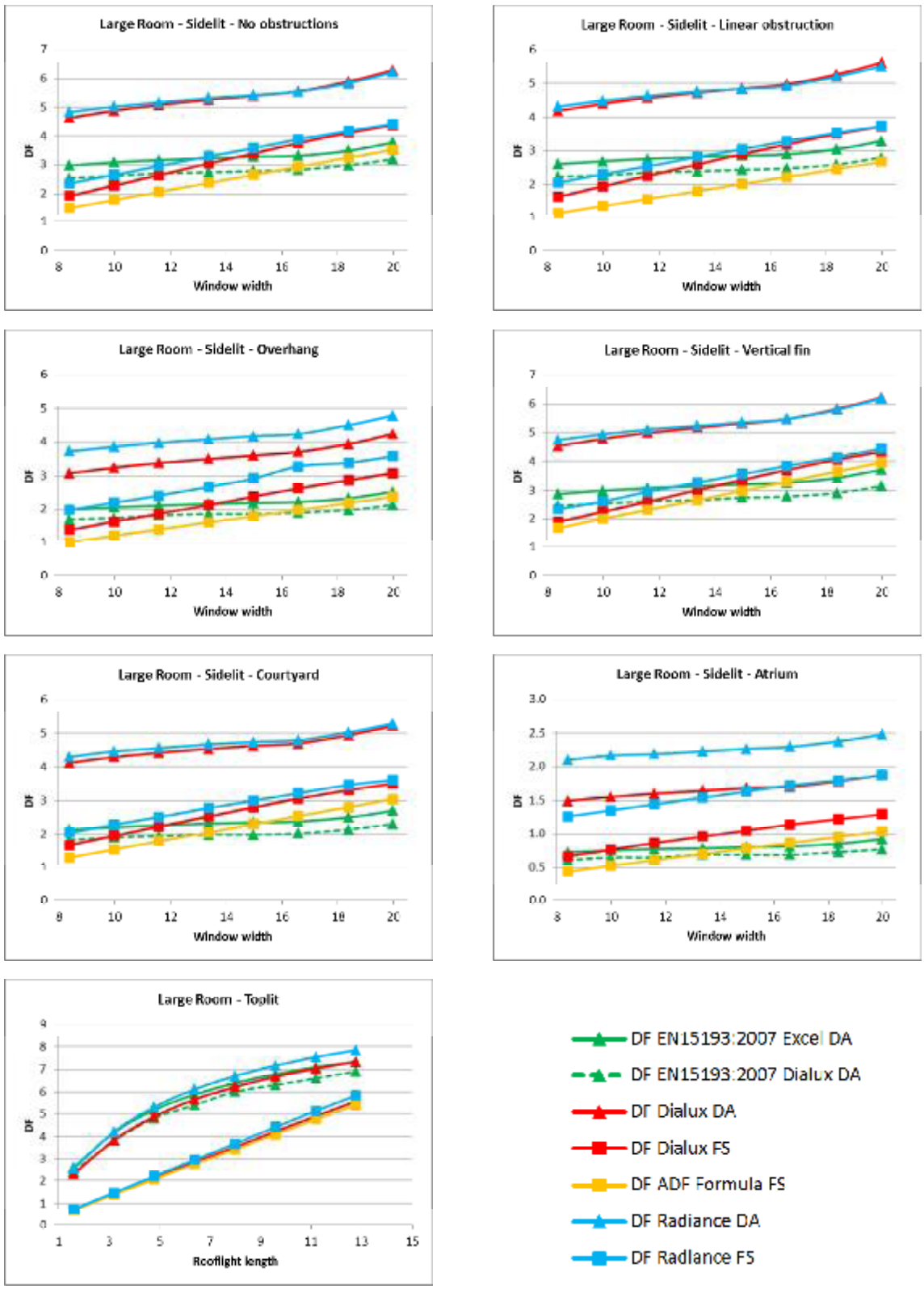


Figure 4.2 Results of daylight factor calculation (in %) in large rooms (DA – daylit area; FS – full space).

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4.3 Small rooms

The calculation results for the small rooms are graphically illustrated in Figure 4.3 and shown in detail in Tables A.2 and A.4 in Appendix A. In the case of small rooms, the daylit area coincided with the entire space in each scene. Table A.6 in Appendix A shows the relative differences between the daylight factor values calculated by Dialux and Radiance computer modelling and the ADF formula, and those calculated in Excel and Dialux using the EN15193 method.

As can be seen from the results, the daylight factor values calculated using the EN15193 method in Excel were slightly higher than those calculated by Dialux using the same method. On average, the daylight factor calculated in Excel was 7% higher than that calculated by Dialux for the side-lit rooms with various obstructions, and 8% higher for the top-lit rooms. Whilst the same behaviour was observed for the daylight factor for the opening (without taking into account the fenestration) and the internal equations used by Dialux could not be verified, it is believed that these differences were due to a different interpretation of the daylit area. It may be that Dialux might have considered a daylit area deeper than the room, in which case the depth index was higher and thus the daylight factor for the opening was lower. Nevertheless, as can be seen in Section 5, these differences did not cause variations in the LENI values calculated by Dialux and in Excel, which were the same for all the scenarios for the small room.

It can also be noted that the daylight factor calculated by the EN15193 method was closest to the daylight factor calculated using the ADF formula. For all the side-lit rooms, the daylight factor calculated in Excel using the EN15193 method was higher than that calculated using the ADF formula by between 1% to 31% on average, depending on the external obstruction scenario. Overall across all side-lit room scenarios, the daylight factor calculated in Excel using the EN15193 method was 13% higher on average (in relative terms) than that calculated using the ADF formula. In the case of top-lit rooms, the daylight factor calculated in Excel using the EN15193 method was 5% lower on average (in relative terms) than that calculated using the ADF formula.

Significantly higher differences can be observed between the daylight factors calculated by Dialux and Radiance and those calculated using the EN15193 method. On the other hand, whilst the daylight factors calculated by Dialux and Radiance using their built-in algorithms were approximately the same for the side-lit rooms (Dialux values were 1% higher on average than Radiance values) and slightly different for the top-lit rooms (Radiance values were 11% higher on average than Dialux values), it can be clearly seen that these values were the highest in all cases. The lowest difference was in the case of the side-lit room with no obstruction, when the daylight factor calculated by Radiance was 25% higher on average than that calculated in Excel using the EN15193 method. The highest difference was for the side-lit room placed in an atrium, with a relative difference of 108% between the same values. Once again the EN15193 method overestimated the impact of the courtyard and atrium. Overall for all the side-lit rooms, the daylight factors calculated by Dialux and Radiance using their built-in algorithms were 54% and 53% higher on average, respectively, than those calculated in Excel using the EN15193 method. Compared to the daylight factors calculated by Dialux using the EN15193 method, the daylight factors calculated by Dialux and Radiance were even higher, by 65% and 64% on average, respectively. The differences were slightly lower in case of the top-lit rooms: on average, the daylight factors calculated by Dialux and Radiance were 16% and 29% higher, respectively, than those calculated using the EN15193 method in Excel, and 25% and 39% higher, respectively, than those calculated using the EN15193 method in Dialux.

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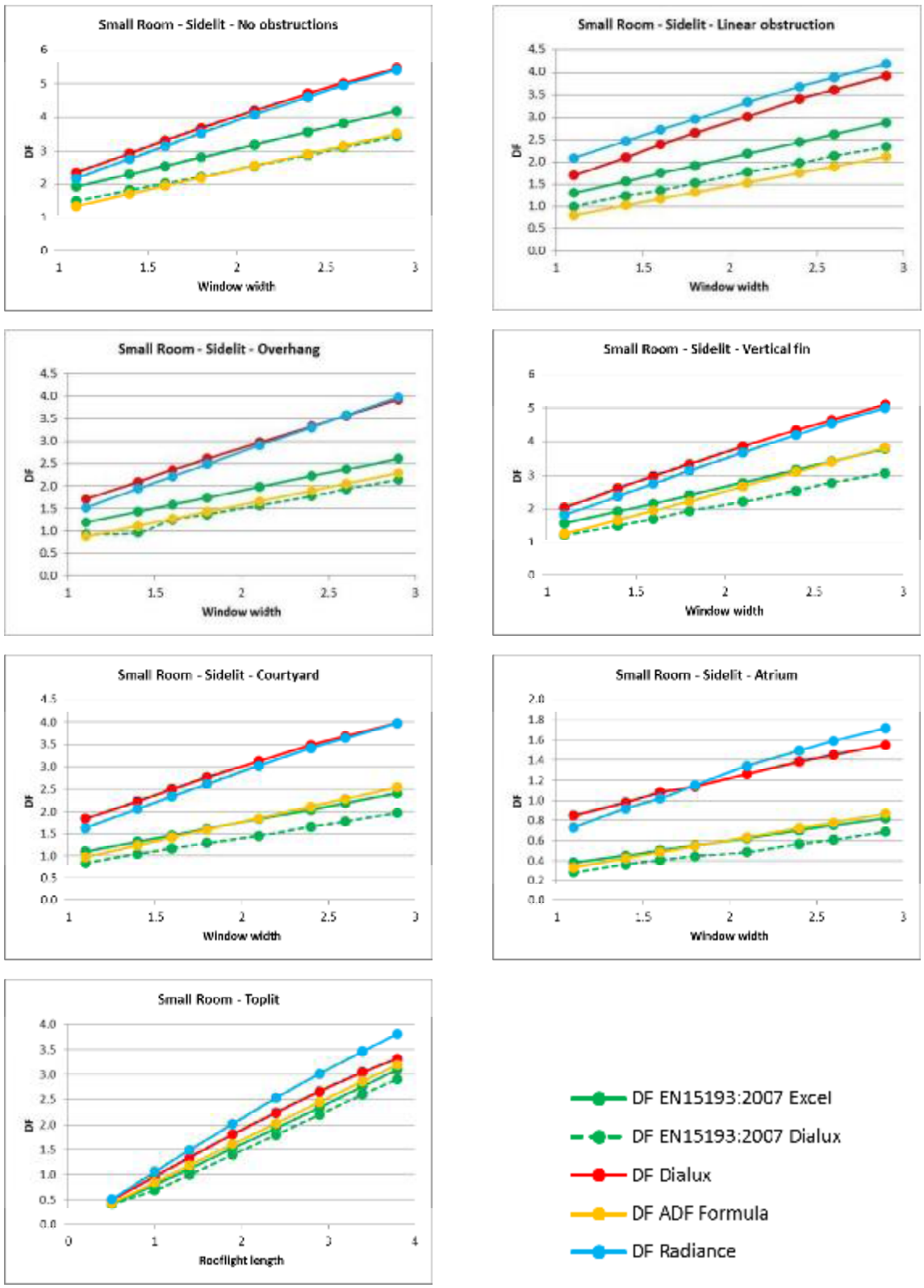


Figure 4.3 Results of daylight factor calculation (in %) in small rooms.

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The fact that the daylight factors calculated in the small rooms using the EN15193 method were lower than those calculated using other methods need not necessarily be a bad thing for lighting use calculation. As explained in the previous section, energy savings from lighting controls are not simply related to the average daylight factor. Instead, the savings from switching or dimming each row of luminaires are more closely related to the minimum daylight factor in the area lit by that row. A lower daylight factor may therefore be more appropriate. Further work is required to confirm this.

In general, the daylight factors calculated using the EN15193 method increased at a slower rate with the glazed area compared to the daylight factors calculated using the other methods. This is of concern because it seems to underestimate the benefits of having wider windows.

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5 Assessment of LENI calculation in EN15193

The LENI calculation is a method for predicting lighting energy use. It relies on equations given in EN15193 'Energy performance of buildings-Energy requirements for lighting' (ref 15) to predict daylight factors and the resulting lighting use for different control strategies.

For the range of example rooms described in Section 4, the LENI was calculated in two ways: using an Excel spreadsheet that the BRE team developed based on the EN15193 equations; and using the energy evaluation module implemented in the specialist lighting modelling software Dialux, in which EN15193 was selected as the calculation standard.

In order to calculate the LENI, an electric lighting system was inserted in each of the example rooms. This consisted of ceiling-recessed LED luminaires placed in symmetrical arrangements to achieve a target illuminance of 500 lux on the working plane: 30 luminaires were placed in an arrangement of 5 rows parallel to the window wall in the large room, and 3 luminaires were spaced equally along the median line perpendicular to the window wall in the small room. Figure B.1 in Appendix B shows the electric lighting systems considered in the example rooms. The electric power consumed by each LED luminaire was 44W, with an assumed additional parasitic power of 0.5W per luminaire for emergency lighting in the large rooms and 1W per luminaire in the small rooms, and of 3W in daylit zones and 2W in non-daylit zones for lighting controls standby.

The example rooms were considered to be offices, and lighting controls were automatic and daylight dependent, with manual switching on and automatic daylight-based dimming (occupancy control factor 0.90), absence detection using one sensor per 10 m^2 (absence factor 0.20) and maintenance of constant illuminance (constant illuminance factor of 0.90). The location chosen for the example rooms was London (latitude 51.5°N and longitude 0.1°W), and annual occupancy hours were considered to be those typical for offices, with 2250 hours of daylight time usage and 250 hours of non-daylight time usage per year.

The LENI was also calculated in each example room using the method proposed in the draft revision of EN15193 (ref 16). Location, room geometry, glazing parameters, obstruction characteristics, electric lighting and usage type were kept similar to those used in the previous calculations based on the method in the current EN15193 standard. To match the previous calculations, no solar or glare protection was added and the type of electric controls was chosen as 'Auto dimmed stand-by losses, switch-on'. In the current EN15193 standard, LENI is independent of orientation, a potential weakness. This has been addressed in a draft for a future revision of the standard (refs 16, 17), which does allow LENI to vary with orientation. Given the new method, three values of LENI were calculated for each side-lit room – corresponding to south, east / west and north façade orientation – and one value for each top-lit room.

The calculation results are graphically illustrated in Figure 5.1 for large rooms and Figure 5.2 for small rooms, and shown in detail in Appendix B: Tables B.1 and B.3 for large rooms and Tables B.2 and B.4 for small rooms.

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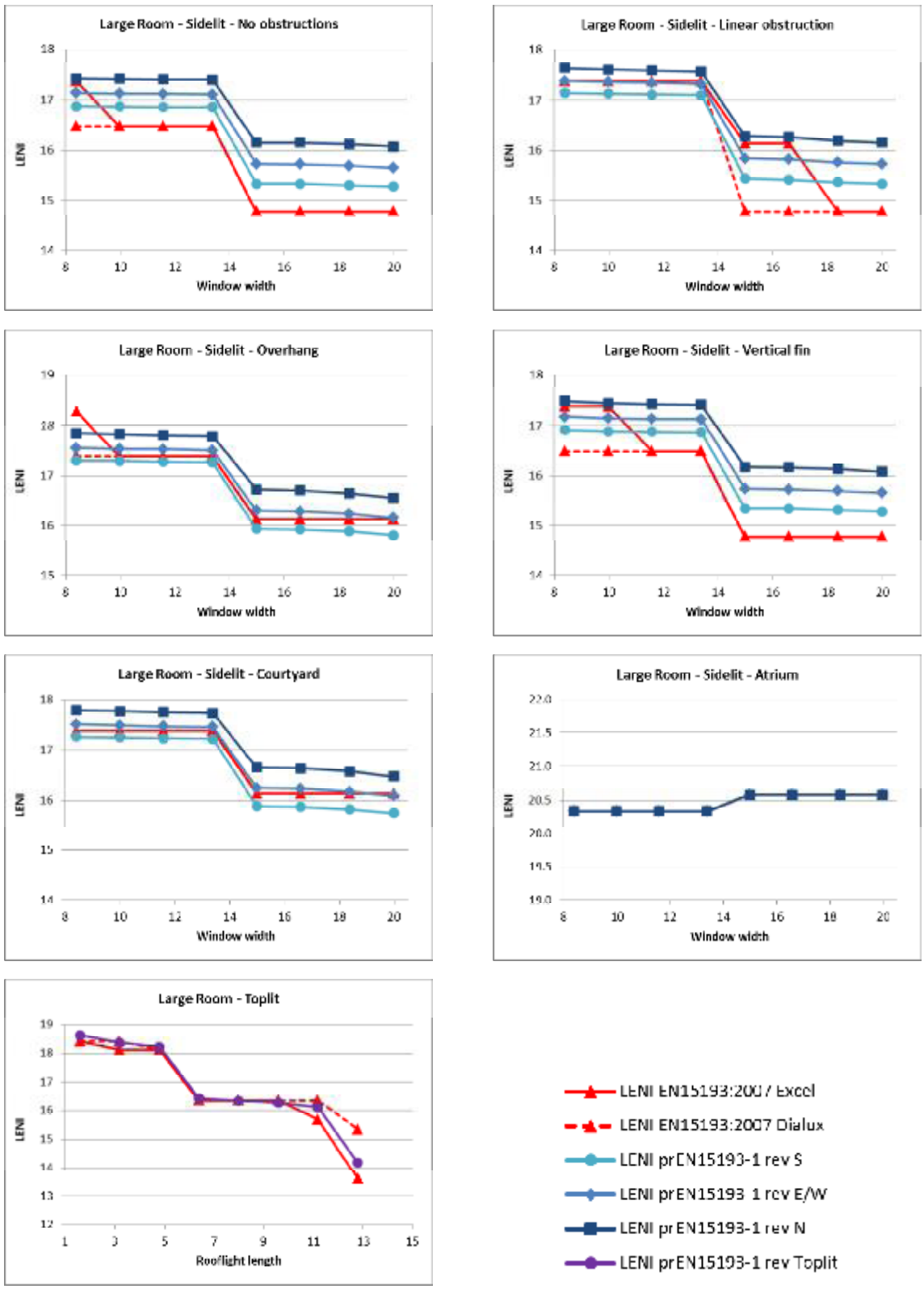


Figure 5.1 Results of LENI calculation (expressed in kWh/m^2,year) in large rooms.

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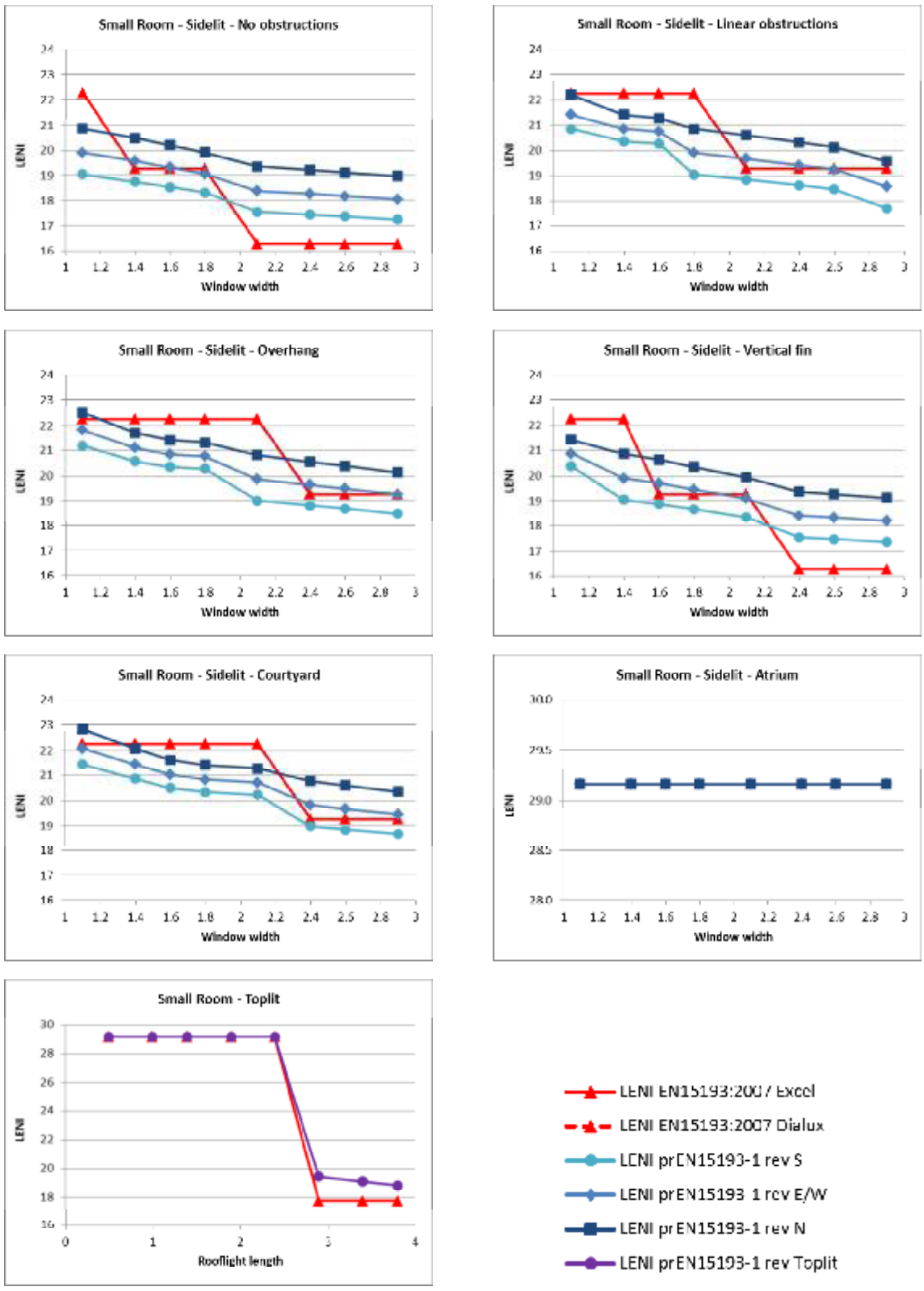


Figure 5.2 Results of LENI calculation (expressed in kWh/m^2,year) in small rooms.

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Whilst the LENI values calculated in Excel and by Dialux using the current EN15193 standard were the same for all the small rooms, there were a number of cases of the large room where these values differed. This was because EN15193 provides two different methods to calculate the LENI from daylight factors. Dialux uses the method based on the carcass façade opening D_c. The Excel spreadsheet used the potentially more accurate method based on final daylight factor D after correction for glazing and framing. This led to different daylight supply classifications for three examples of the top-lit large room, two examples of the side-lit large room with linear obstruction and with vertical fin, and one example of the side-lit large room with no obstruction and with overhang. The LENI values were the same for all the side-lit large rooms placed in a courtyard or an atrium.

As can be seen from the results, although the daylight factor calculations described in Section 4 showed a continuous increase of the daylight factor with the glazing area for all the example rooms, the LENI followed a more constant trend. As expected, the LENI decreased with the glazed area. Nevertheless, since the hypotheses of the calculations assumed automatic controls with daylight-based dimming, one could also expect that the electricity consumed by the electric lighting would vary gradually with the amount of daylight available in the space. However, the LENI calculations show that the LENI varied very little with the glazed area and implicitly with the daylight factor.

Based on the method in the current EN15193 standard, there were in general two or three values of LENI determined in each scenario, although there were eight scenes with different glazing areas in each scenario. More variation was noted for the large top-lit room, with five values of LENI across the eight scenes, whilst the LENI was constant for all the eight scenes of small side-lit rooms placed in an atrium.

In the case of large rooms, this trend did not change with the method proposed in the draft revision of EN15193 as the LENI only varied very slightly across the eight scenes in each scenario, despite the different glazed areas. More variation was noted for the top-lit large room. As regards the small rooms, the method proposed in the draft revision of EN15193 led to a more gradual variation of LENI with the glazed area in the side-lit rooms, except that placed in an atrium for which the LENI was constant for all the eight scenes. Less variation was noted for the top-lit small room.

With the exception of the side-lit rooms placed in an atrium, the LENI values calculated using the method proposed in the draft revision of EN15193 differed for each façade orientation of the side-lit rooms: LENI was the highest for windows facing due north and the lowest for windows facing due south, with intermediate values for windows facing due east or west.

In general, the LENI determined using the method proposed in the draft revision of EN15193 appeared to be on average higher than the LENI calculated using the method in the current EN15193 standard if the side-lit rooms had no external obstruction or if the rooms were lit by rooflights. This was also the case for the large side-lit room with vertical fin. For the other room examples, the LENI determined using the method proposed in the draft revision of EN15193 was higher or lower than the LENI calculated using the method in the current EN15193 standard depending on façade orientation and glazed area. No difference was noted for the side-lit rooms placed in an atrium.

The results of the LENI calculations undertaken for the whole range of example rooms show that the classification of daylight levels into a limited number of categories, both in the current EN15193 standard and in the draft revision, gives a stepped and narrow variation of lighting energy use with glazing area, rather than the continuous function achieved in practice by using daylight-based dimming controls. First, in calculating the LENI daylit spaces are grouped into four categories, ‘strong’ ‘medium’ ‘low’ and ‘none’. Instead of having a steady effect, increasing window area led to no change in LENI at all initially, followed by a sudden drop in LENI as the daylit space reached another category, then no change again even though in reality daylight was steadily improving. This gives misleading results, especially in parametric studies where designers may vary window sizes to try to improve LENI.

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For side lit spaces without solar shading in the newly proposed version of EN15193, this method has been replaced by a table (Table F4 in the proposed standard) which gives daylight supply factor (the parameter which indicates the effect daylight has on lighting use) as a direct function of daylight factor. In principle this should improve the calculation. However the results seem to show that under the new calculation system LENI does not vary significantly with daylight, even if the glazing area is doubled.

For top lit spaces, the method in the newly proposed EN15193 is still based on classifying them into four categories, ‘strong’ ‘medium’ ‘low’ and ‘none’, resulting in similar big jumps in LENI.

There is another artefact in the equations which introduces jumps in LENI as window width changes. This happens in both the previous and new versions of EN15193. In the large room, as window width increases the daylit zone gets larger. During this process, an extra pair of luminaires comes into the scope of the daylit zone. This pair of luminaires can then be dimmed in response to daylight. In principle this could be a real effect, although in practice the entire row of luminaires nearest the window wall would probably be controlled together. This effect would not happen in the small room which just has one luminaire in each row.

Chapter 6 of this report describes additional analysis to evaluate the LENI method against climate based daylight modelling approaches using the same range of example rooms.

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6 Assessment of climate based daylight prediction

Computer modelling of daylight was carried out using Daysim 3.1 (under Ecotect Analysis 2011) to determine Daylight Autonomy (DA) and Useful Daylight Illuminance (UDI) for a selection of the example rooms described in Section 4.

Daysim is a daylighting analysis software tool that calculates the annual availability of daylight in buildings by combining the Radiance backward ray-tracing method with a daylight coefficient approach using the Perez all weather sky model. Indoor illuminances can be calculated at user defined sensor points based on hourly mean direct and diffuse irradiance values derived from weather files.

Climate based daylighting metrics are derived from the resulting time series of illuminances. Daysim calculates Daylight Autonomy (DA) and Useful Daylight Illuminance (UDI) to summarise the daylight availability over a year throughout a space. Annual illuminance profiles can also be linked with user occupancy data to predict the annual use of electric lighting in a building zone depending on the lighting load, lighting controls type and blind control strategy. Daysim can also calculate the Daylight Factor (DF) and Daylight Glare Probability (DGP) to predict discomfort glare from daylight for different viewpoints in a scene throughout a year. Assessment of Daylight Glare Probability was outside the scope of this report.

From the various room models used for the daylight modelling and LENI assessment described in Sections 4 and 5, three types were chosen with the widest, narrowest and an intermediate daylight opening. For the large rooms, both single and equally spaced multiple openings were chosen. This is shown in Table 6.1 below.

Table 6.1: Room models considered for climate based daylight modelling

Room size and type		Daylight opening size*			
		Small	Intermediate		Large
			Single opening	Multiple openings	
Large room	Side-lit	8.4m x 1.8m	15.0m x 1.8m	3N x 5.0m x 1.8m	20.0m x 1.8m
	Top-lit	1.6m x 2.0m	8.0m x 2.0m	4N x 2.0m x 2.0m	12.8m x 2.0m
Small room	Side-lit	1.1m x 1.6m	2.1m x 1.6m		2.9m x 1.6m
	Top-lit	0.5m x 0.5m	2.4m x 0.5m		3.8m x 0.5m

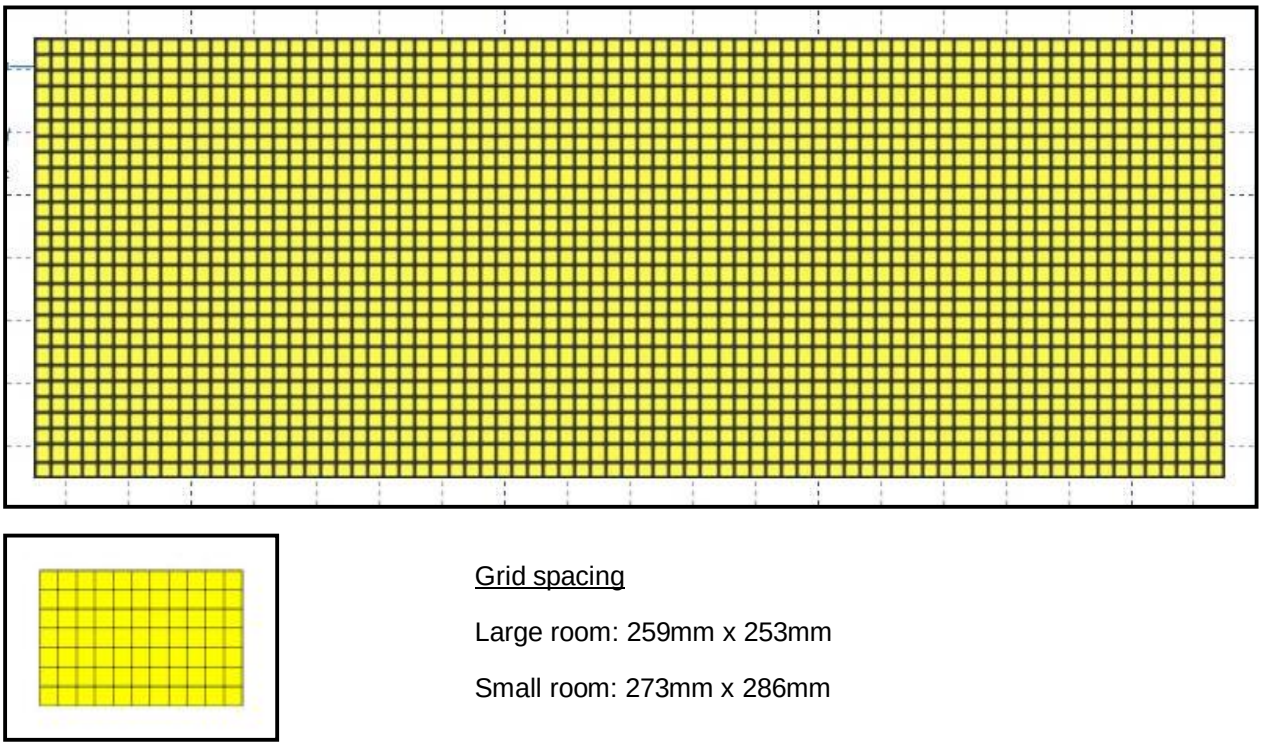
** W x H for windows and L x W for rooflights*

All the side-lit rooms listed in Table 6.1 were modelled without external obstruction and with linear obstruction, overhang and courtyard. All the top-lit rooms were modelled without external obstruction. The properties of the glazing and room and obstruction finishes were kept similar to those detailed in Section

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4. Each room was modelled with the working plane grid at 0.8m above the floor and with an offset distance of 0.5m from the walls. Figure 6.1 shows the grid of points for the large room and small room models.



Grid spacing

Large room: 259mm x 253mm

Small room: 273mm x 286mm

Figure 6.1 Working plane grid used for large room (top) and small room (bottom) models.

Daysim modelling was carried out using the Ecotect WEA climate weather file for London with the default Radiance simulation parameters and static shading devices. Three types of occupancy were modelled:

- School, occupancy hours 08:30-16:00
- Office 1, occupancy hours 08:30-17:30
- Office 2, occupancy hours 06:00-18:00

No lunch or intermediate breaks were considered, and daylight savings time was included in the calculations. Default Daysim settings for occupant behaviour were used, consisting of active blind control, with users avoiding direct sunlight on the working plane.

Each scenario was modelled with a minimum illuminance level of both 300 lux and 500 lux. The results are given in Appendix C. For each scenario modelled, the following average values were determined from the Daysim calculation results:

- Average DF across the working plane grid, marked ADF
- Average DA across the working plane grid, marked DA500 and DA300
- Average UDI values across the working plane grid, using Daysim default UDI ranges: UDI-s for E < 100 lux, UDI-a for 100 lux ≤ E ≤ 2000 lux and UDI-e for E > 2000 lux

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The percentage area of the working plane grid with point DA of at least 50%, or the spatial Daylight Autonomy for 50% of operating hours, was also calculated for each scenario modelled.

In addition, point values of the above factors were also calculated for each scenario at the end of each luminaire row, considered at 0.5m away from the side wall. Luminaire positions in each room were taken to be the same as those used for the LENI calculations described in Section 5. Where the end of a luminaire row did not coincide with a point on the calculation grid, point values were determined by interpolation from the data calculated for the closest points placed on the grid edge at 0.5m away from the wall. This is shown in Figure 6.2.

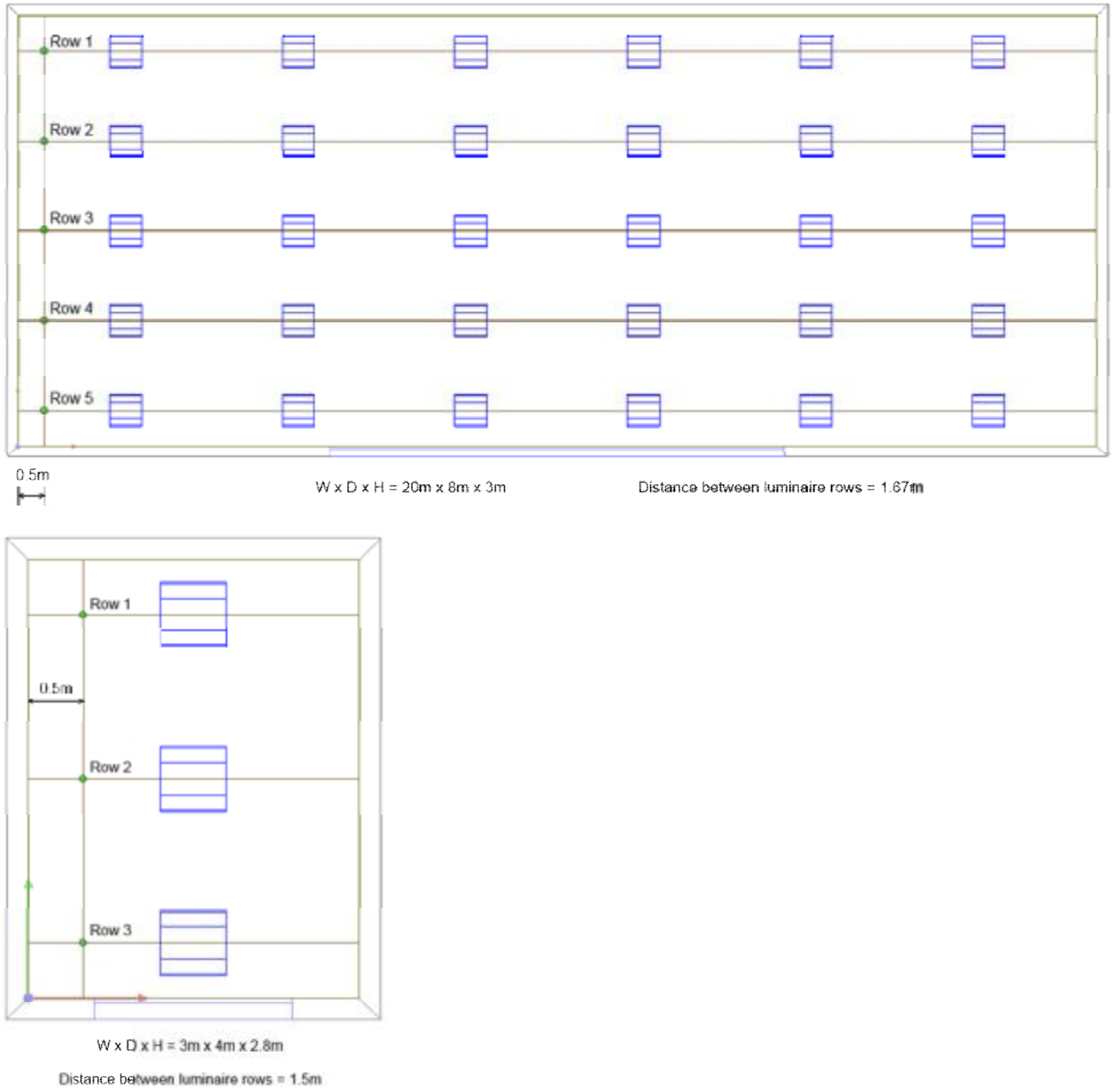


Figure 6.2 Calculation points corresponding with luminaire row ends used for large room (top) and small room (bottom) models.

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The purpose of carrying out specific calculations for the ends of the luminaire rows is because these points are critical for the operation of photoelectric controls. If a lighting system is controlled by switching individual rows, the relevant switching illuminance is at the end of each row because that is the worst lit point. Thus the percentage saving from an on/off photoelectric control, switching each row of luminaires separately, is equal to the average of the daylight autonomies at the end of the rows (see section 2.4 above). This ignores parasitic losses in the control, and the potential use of a differential switching or time delay strategy to reduce unwanted switching operations (section 3.2).

The average DA and UDI-a across the working plane were compared to each other and with the average daylight factor ADF calculated by Daysim. The point DA values calculated for all luminaire row ends in each room modelled were averaged, and both this average and the average DA across the entire working plane were compared with the daylight dependency factor FD calculated using the methods given in the current EN15193 standard (ref 15) and in the newly proposed version of EN15193 (ref 16). When calculating FD, automatic daylight dependent controls were considered for the method given in the current EN15193 standard, and auto switched on/off controls for that given in the newly proposed version of the standard. Because FD is calculated for the daylight zone only, area weighted values of FD were considered for the entire rooms (based on FD=100% in the non daylit areas). In addition, the value of 100% – FD (with FD in percent) was used instead of FD in order to have a similar trend as that of DA against which it was compared (100%-FD is the percentage saving, compared to FD which is the fractional lighting use).

Figures 6.3 to 6.40 show the comparisons listed above for the large and small rooms used as offices with working hours 08:30-17:30 and a target illuminance level of 500lux. The values represented in Figures 6.3 to 6.30 correspond to all of the scenarios of external obstruction considered, whilst Figures 6.31 to 6.40 show the values obtained for each scenario of external obstruction separately.

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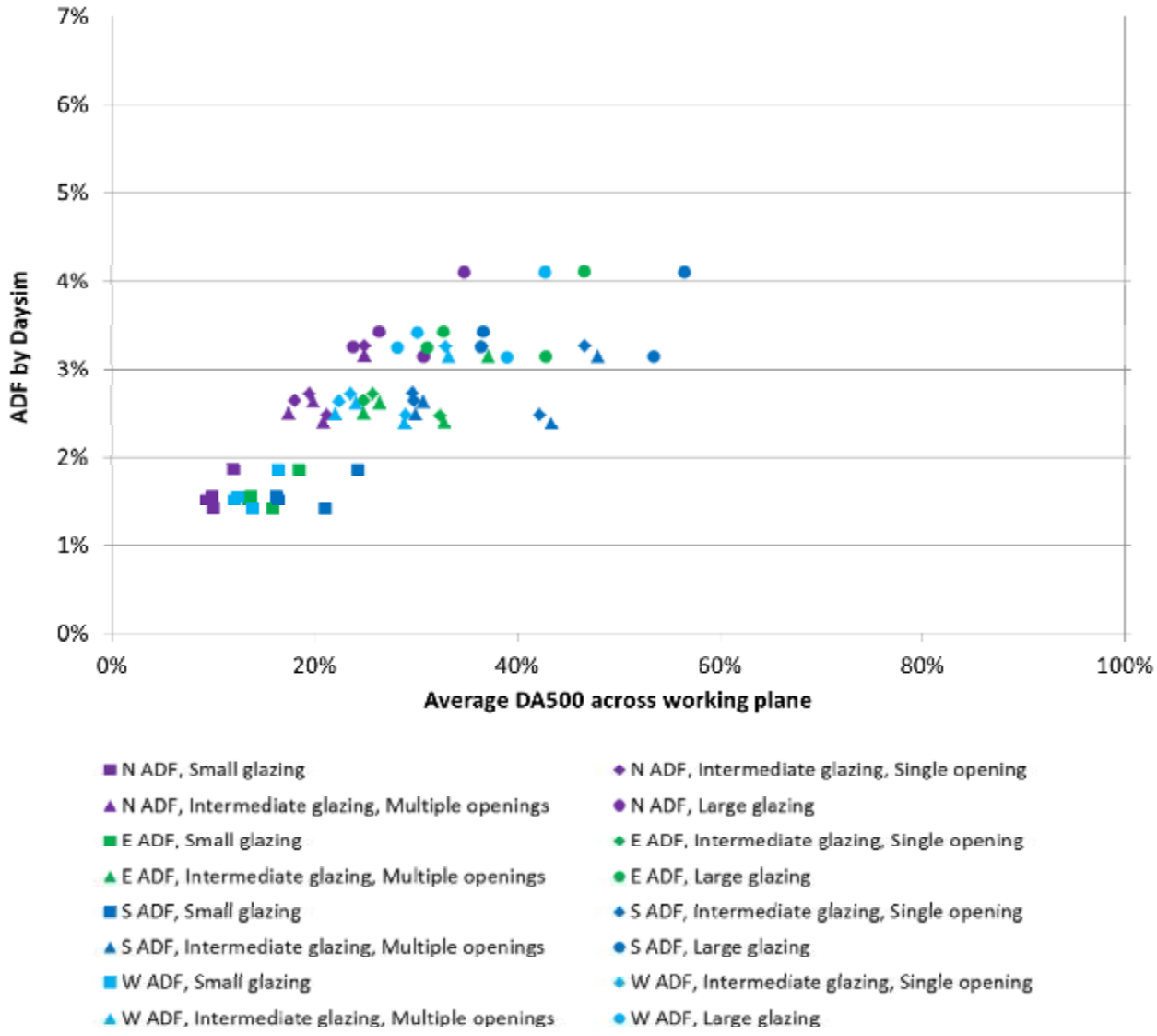


Figure 6.3 Average daylight factor ADF versus average daylight autonomy DA500 across the working plane for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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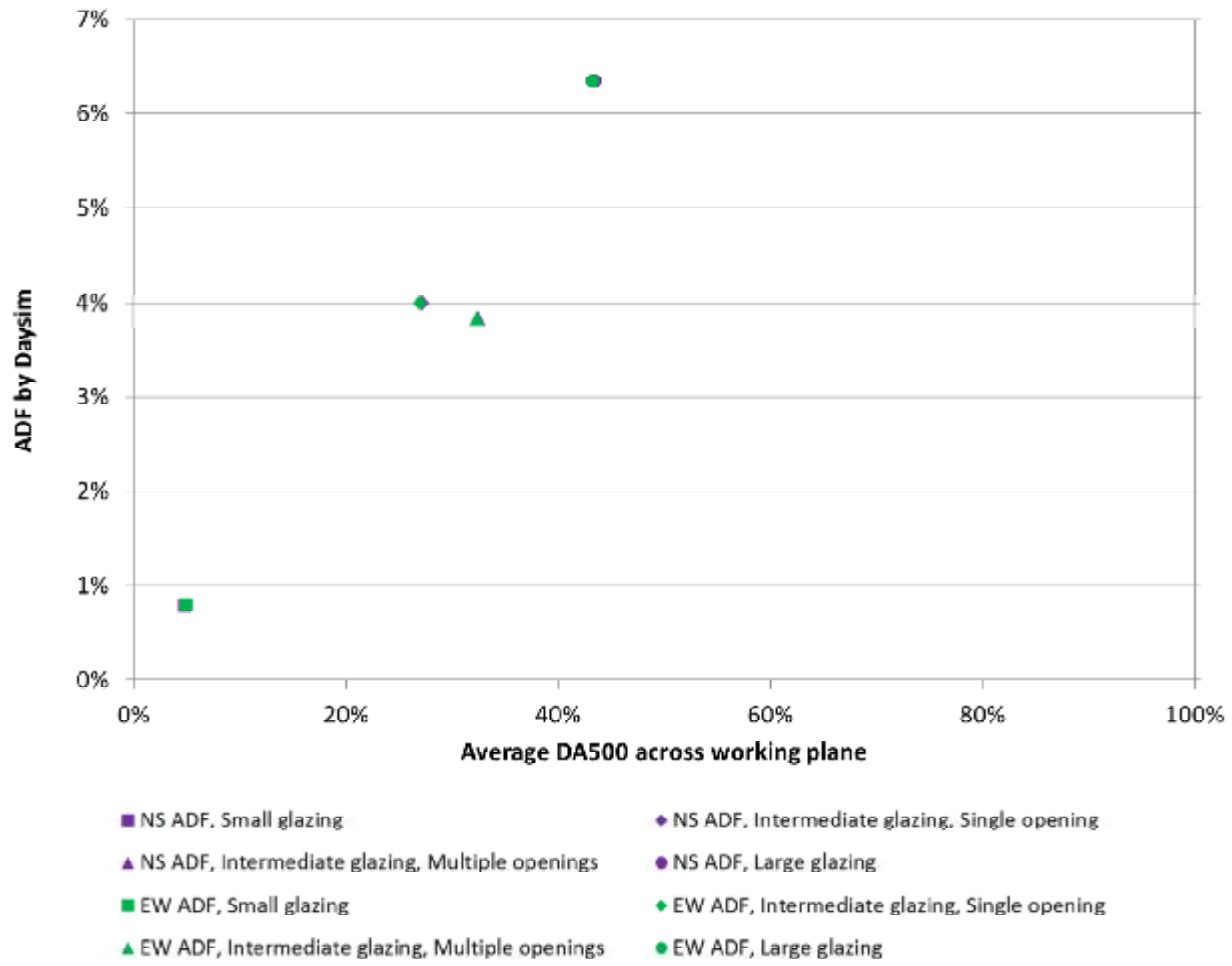


Figure 6.4 Average daylight factor ADF versus average daylight autonomy DA500 across the working plane for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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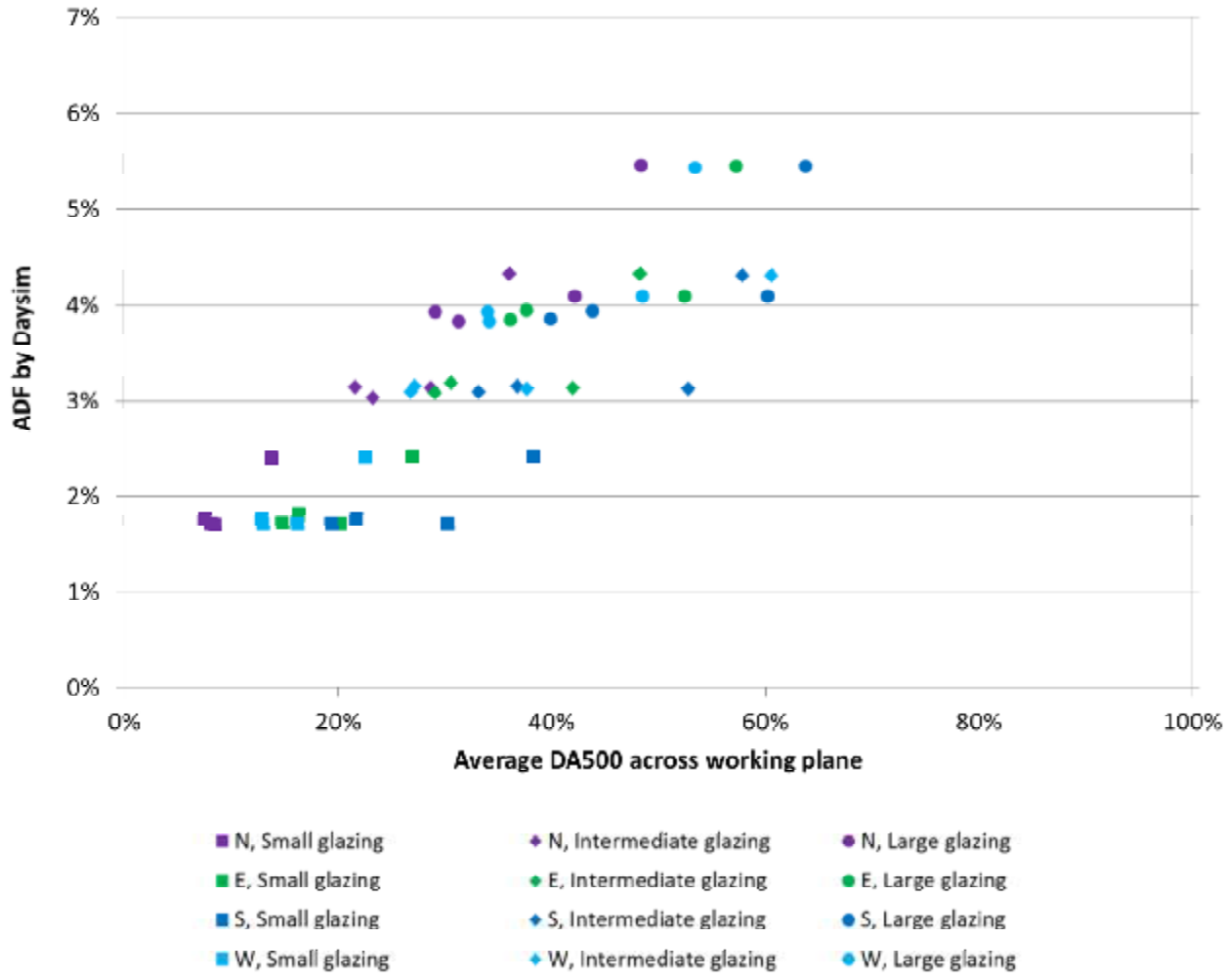


Figure 6.5 Average daylight factor ADF versus average daylight autonomy DA500 across the working plane for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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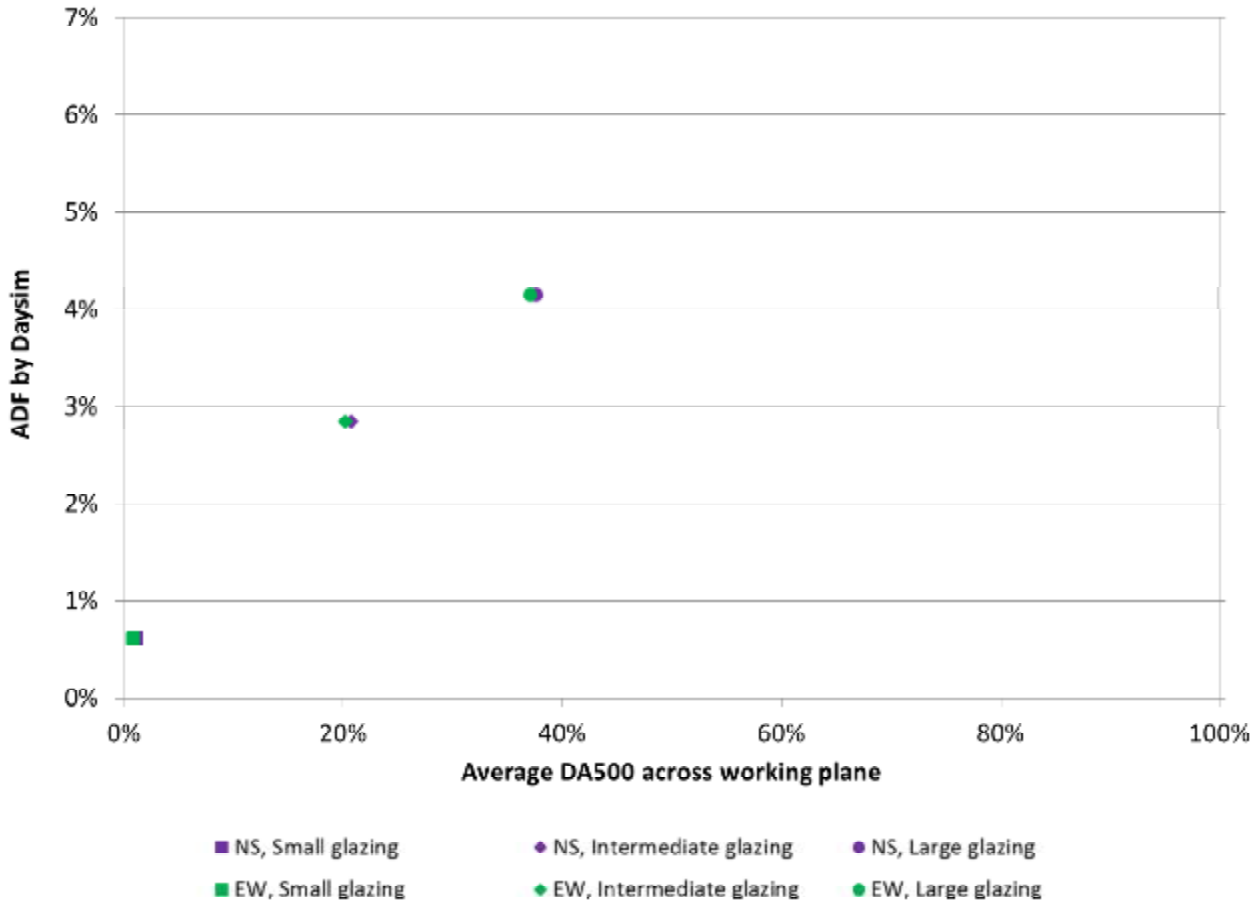


Figure 6.6 Average daylight factor ADF versus average daylight autonomy DA500 across the working plane for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

As can be seen in Figures 6.3 to 6.6, ADF remains constant irrespective of window or rooflight orientation. However, as expected, DA500 varies with the façade orientation for the side-lit rooms, being highest for the south facing rooms and lowest for the north facing rooms. Due to the choice of working hours, DA500 is higher in the east facing rooms compared to the west facing ones. There is virtually no variation in DA500 with rooflight orientation.

As expected, both ADF and DA500 rise with glazing area. However, DA500 is relatively low for an ADF of 2% regardless of other factors. DA500 is above 50% only for the large side-lit rooms facing due south, having large glazing and either no external obstruction or an overhang. For these rooms, ADF is just above 3% and 4%, respectively. For the same scenarios of external obstruction, the small side-lit rooms with large glazing can have DA500 above 50% both for south orientation as above, and for east and west orientations. In these cases, ADF ranges from just above 4% to 5.5%. DA500 is below 50% for all top-lit rooms, even if ADF goes up to 6.3% in case of the large room.

The DA500 presented in the graphs is a relatively ‘tough’ metric because it is based on achieving a higher illuminance for a lengthy period of time (500 lux for half of a full 0830-1730 working year). Other versions of DA, for example based on 300 lux for a school year, would be easier to achieve (see section 2.4) and a 50% value would correspond to lower average daylight factors.

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Dividing the glazing into multiple smaller openings rather than having a single larger opening helps increase slightly the average DA500 across the working plane, because uniformity is better. On the other hand, DA500 appears to be slightly lower in the small rooms compared to the large rooms, whilst ADF is within the same order of magnitude.

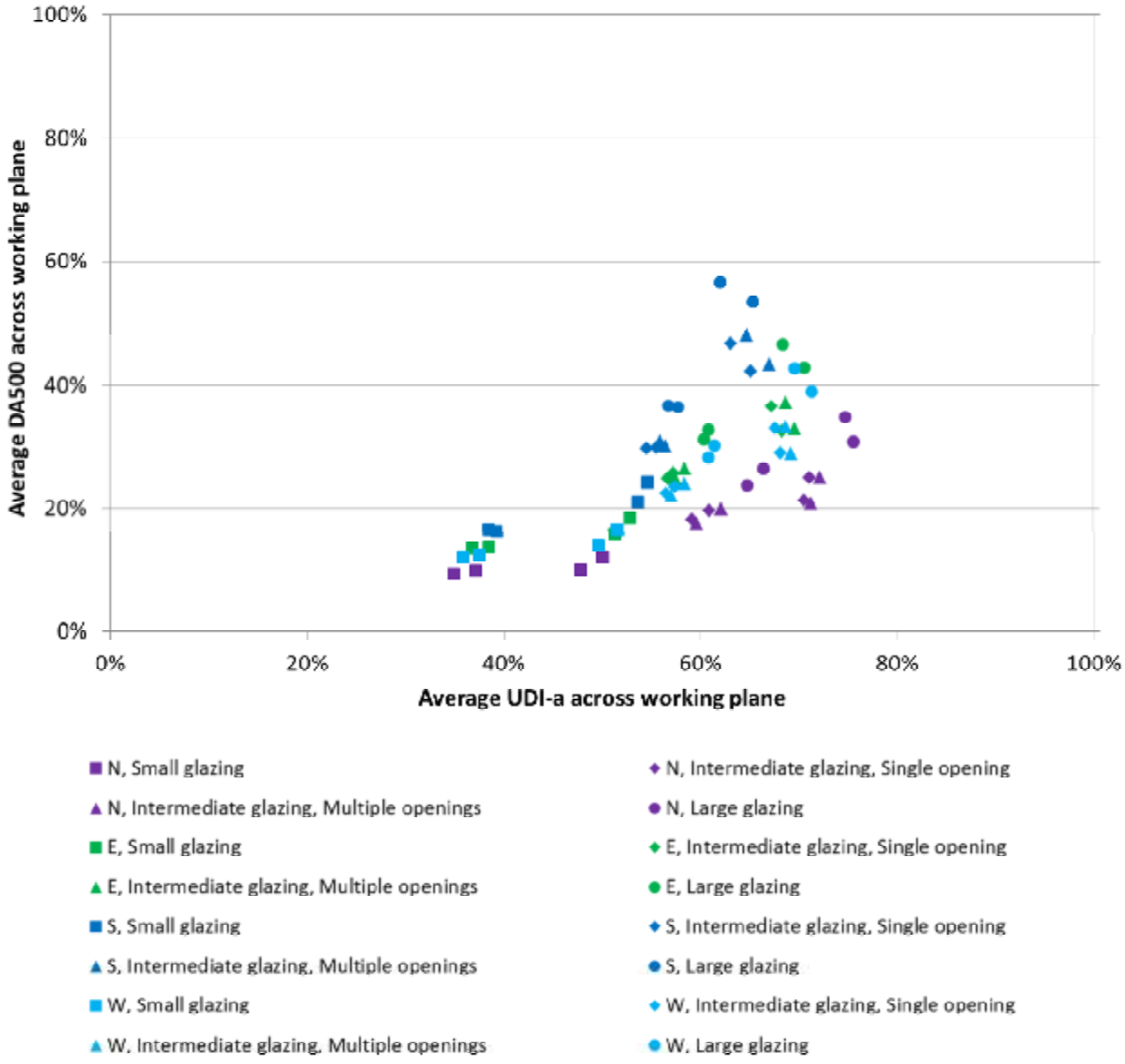


Figure 6.7 Average daylight autonomy DA500 versus average useful daylight illuminance UDI-a across the working plane for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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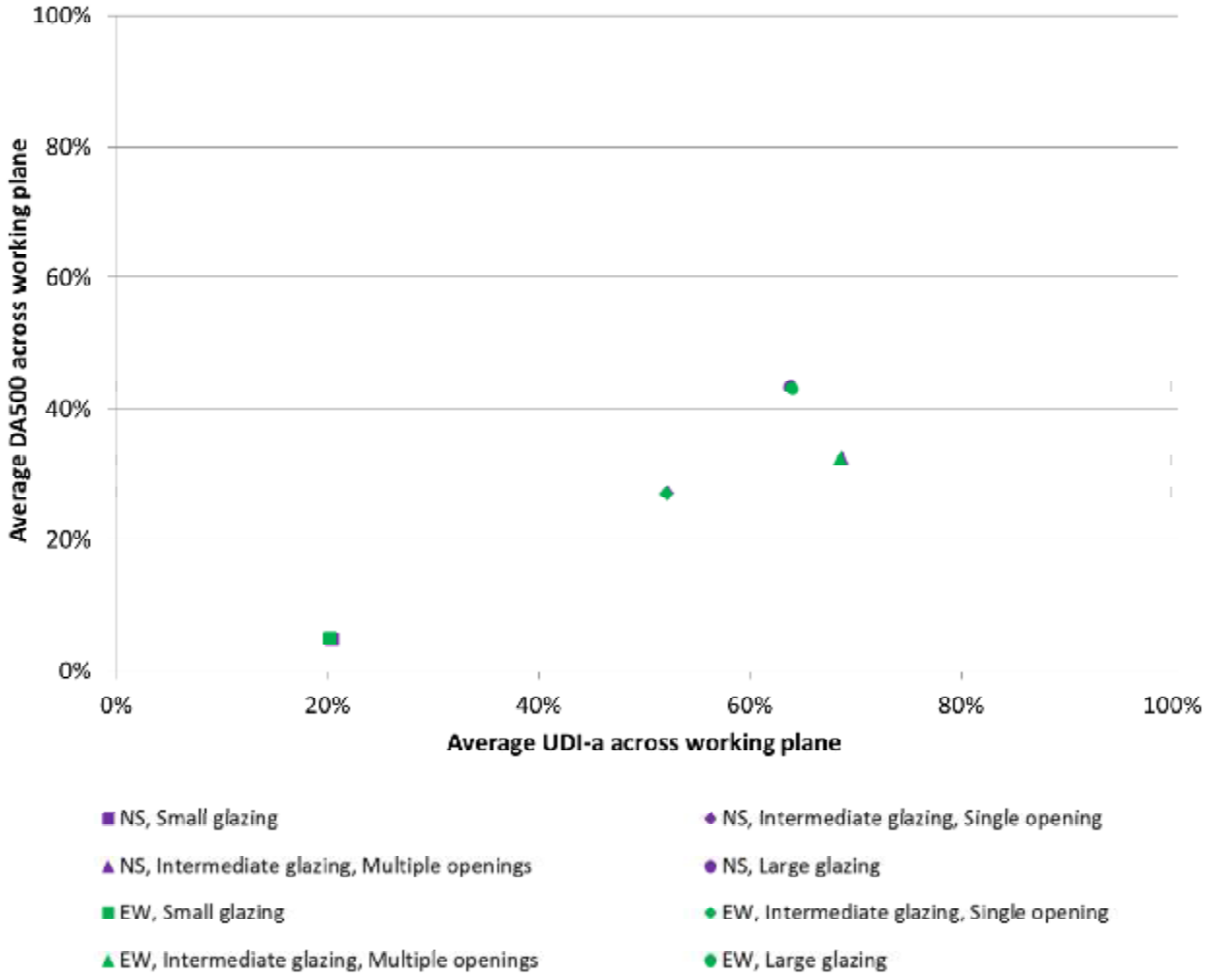


Figure 6.8 Average daylight autonomy DA500 versus average useful daylight illuminance UDI-a across the working plane for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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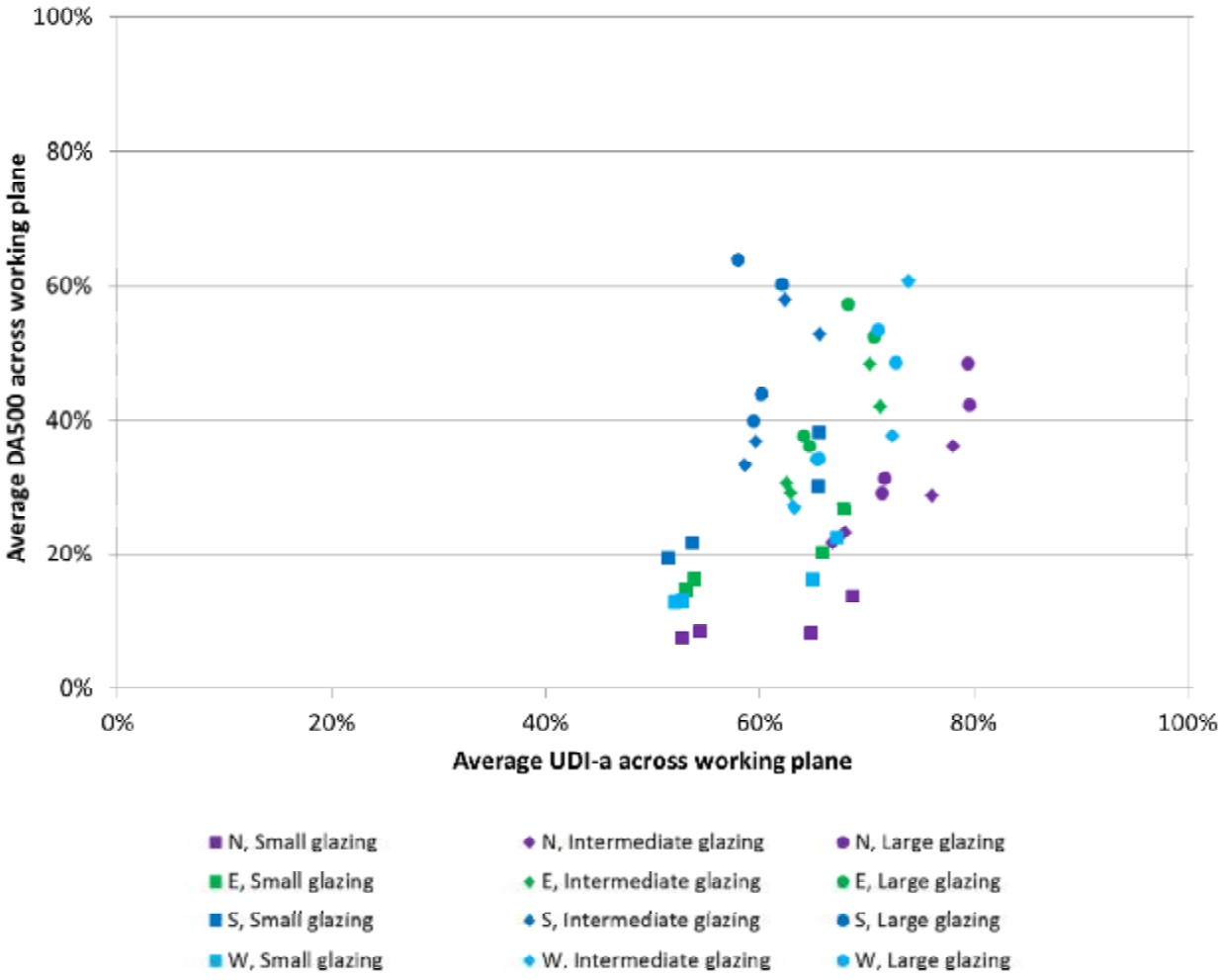


Figure 6.9 Average daylight autonomy DA500 versus average useful daylight illuminance UDI-a across the working plane for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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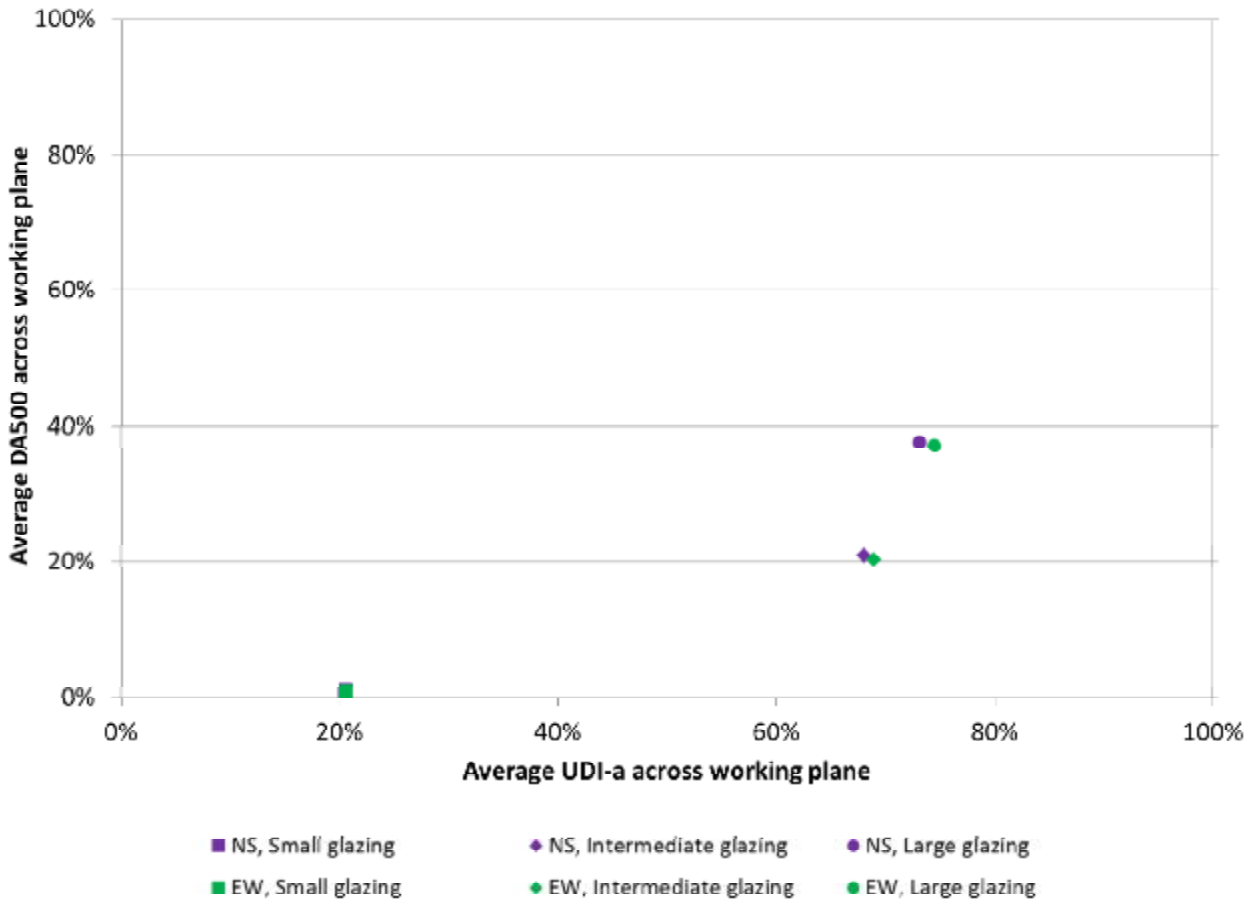


Figure 6.10 Average daylight autonomy DA500 versus average useful daylight illuminance UDI-a across the working plane for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

From Figures 6.7 to 6.10, it can be noted that it is easier to achieve higher UDI-a values than higher DA500 values in both large and small rooms. This is because of the lower bottom threshold for UDI-a. In all cases, UDI-a is also higher than DA500 and, as expected, both factors rise with glazing area. However, higher DA500 values do not necessarily lead to higher UDI-a values. In effect, UDI-a rises with glazing area and DA500 up to a point where daylight contribution starts to count towards UDI-e.

By having multiple openings instead of a single larger one, UDI-a becomes slightly higher. For the large top-lit room, the UDI-a for intermediate glazing divided in multiple opening is even higher than the UDI-a for large glazing due to the more uniform daylight distribution achieved by placing the rooflights more evenly across the room.

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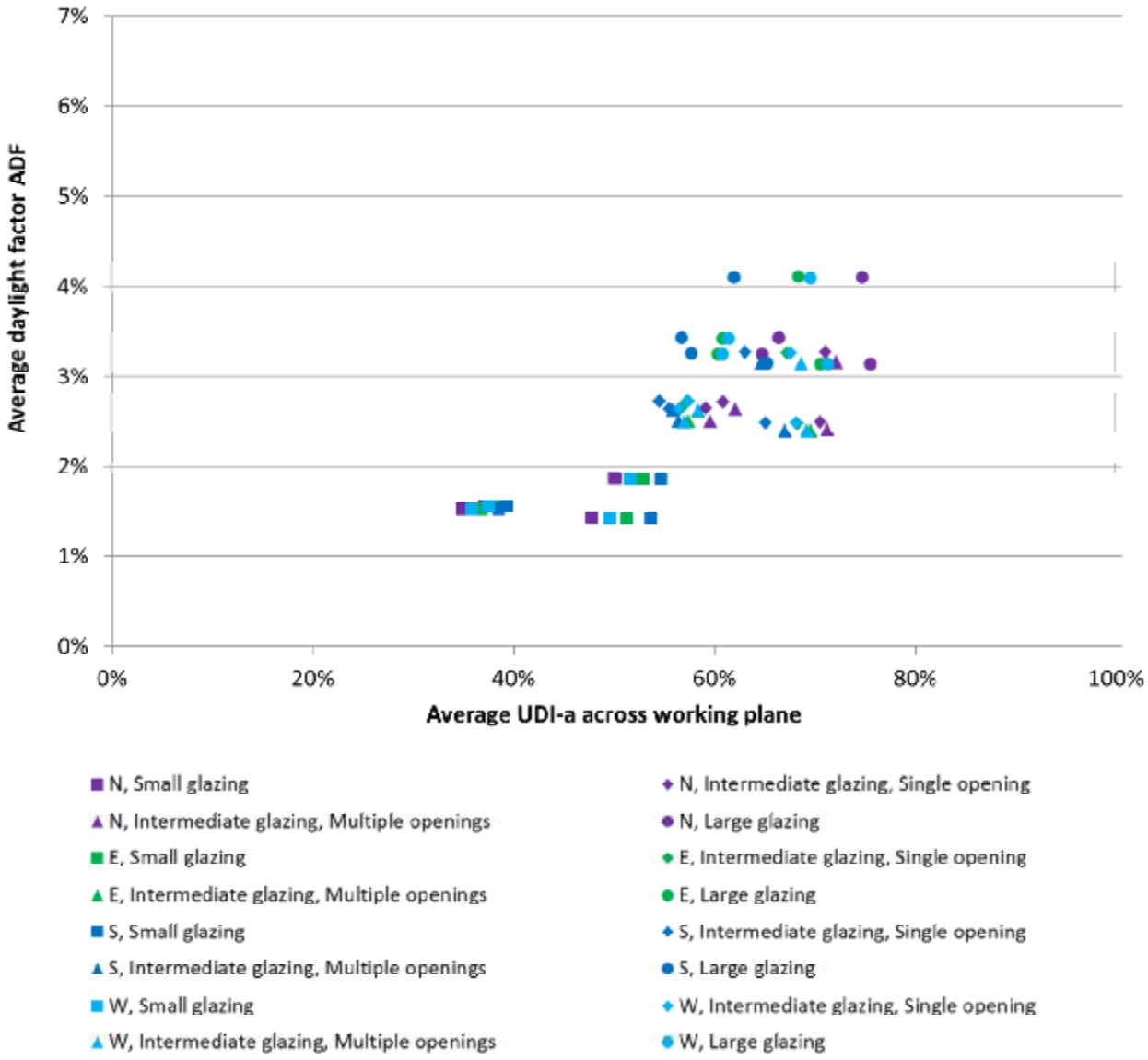


Figure 6.11 Average daylight factor ADF versus average useful daylight illuminance UDI-a across the working plane for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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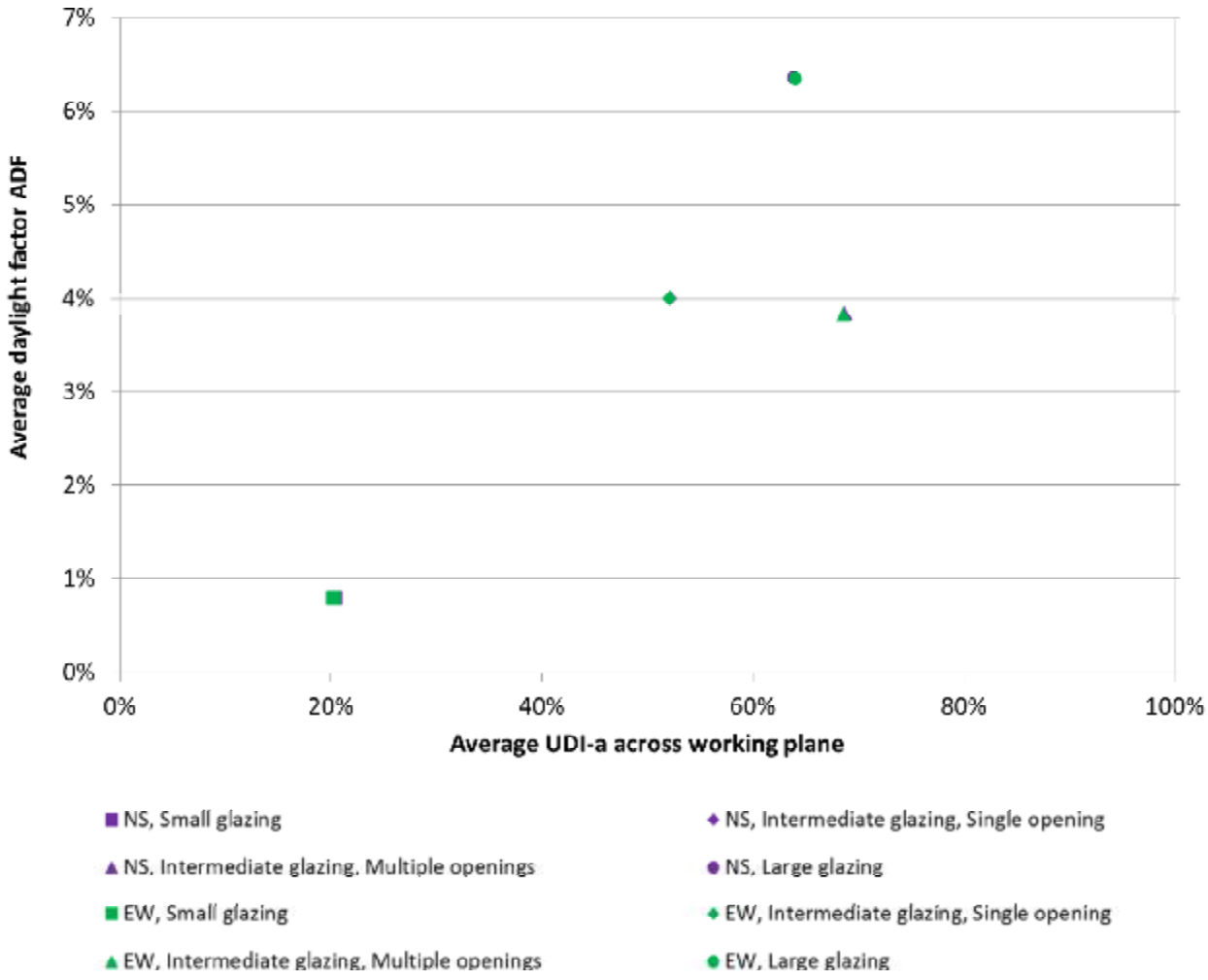


Figure 6.12 Average daylight factor ADF versus average useful daylight illuminance UDI-a across the working plane for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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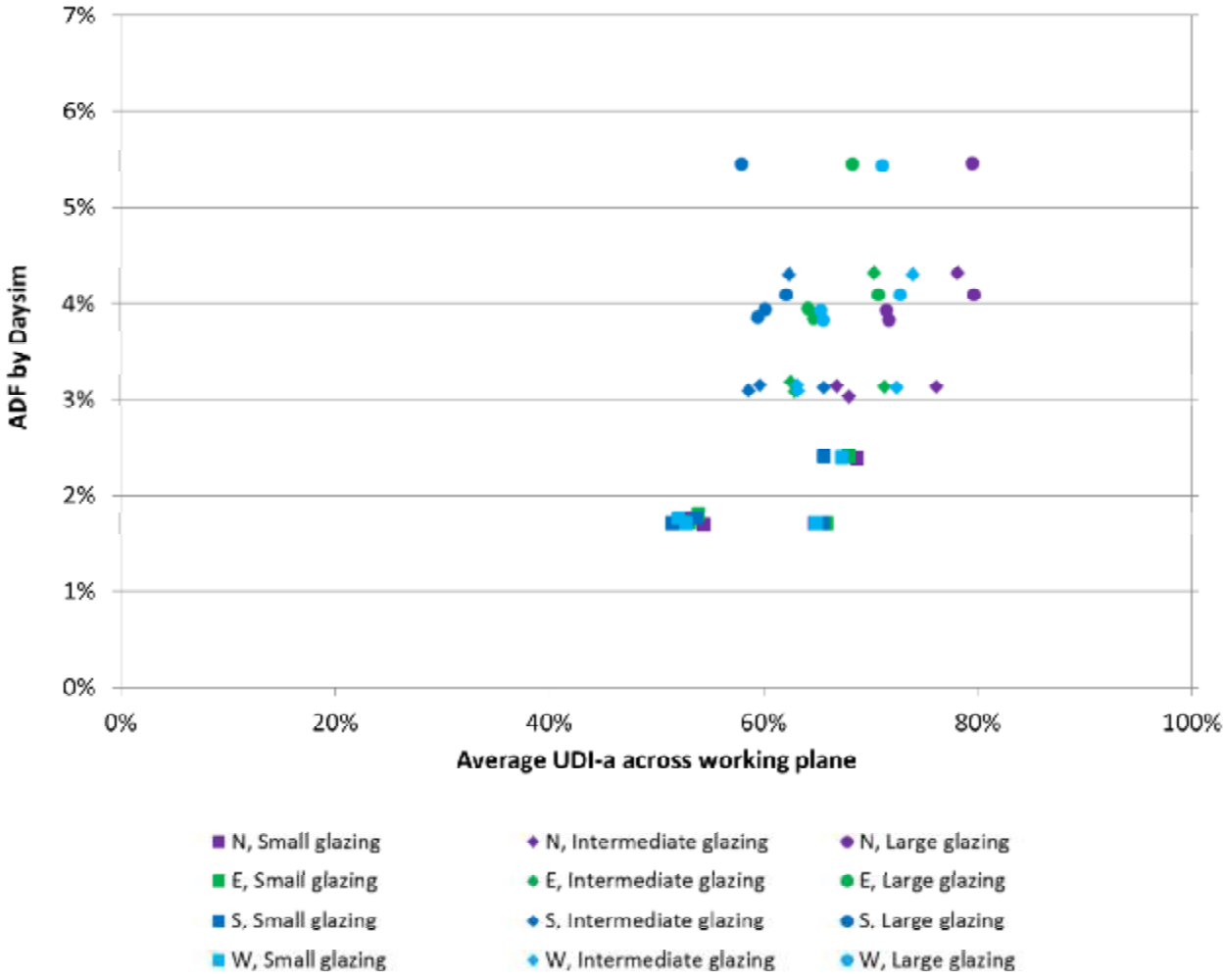


Figure 6.13 Average daylight factor ADF versus average useful daylight illuminance UDI-a across the working plane for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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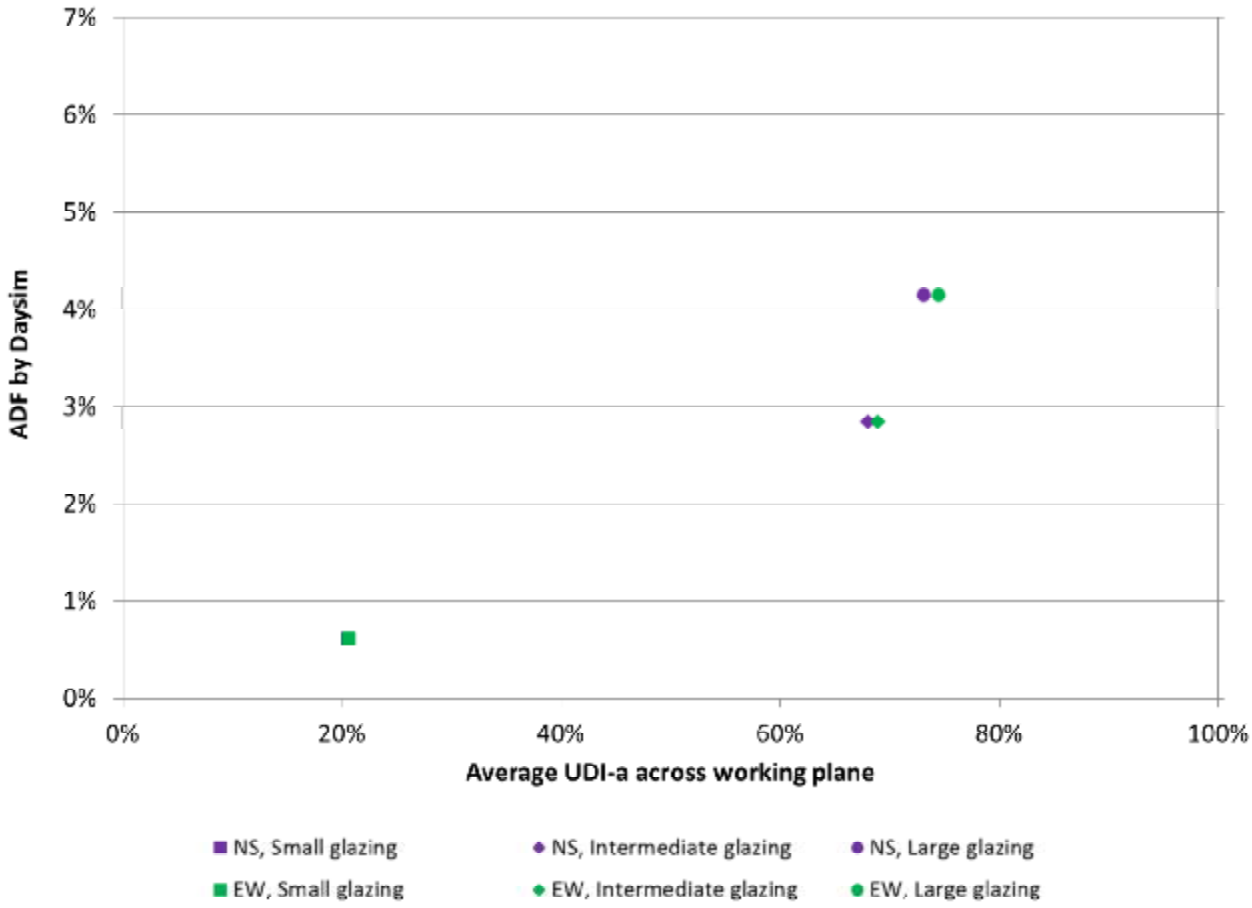


Figure 6.14 Average daylight factor ADF versus average useful daylight illuminance UDI-a across the working plane for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

As previously, Figures 6.11 to 6.14 also show that ADF does not vary with glazing orientation but only with glazing area.

It can also be noted that UDI-a can be influenced by both glazing orientation and glazing area. For large side-lit rooms with smaller glazing, UDI-a is highest for south facing windows and lowest for north facing windows; it is slightly higher for west façades compared to east façades. However, for large side-lit rooms with larger glazing the reverse applies. The same tendency can be observed for small side-lit rooms, but there is less impact for smaller glazing.

UDI-a does not appear to vary with rooflight orientation for large rooms, but for small rooms it appears to rise more with glazing area for an east-west orientation compared with a north-south one.

Also, UDI-a does not vary proportionally with glazing area. In general, smaller daylight openings generate higher UDI-s whilst larger daylight openings generate higher UDI-e, both in the detriment of UDI-a. Hence, UDI-a tends to be higher for intermediate glazing areas.

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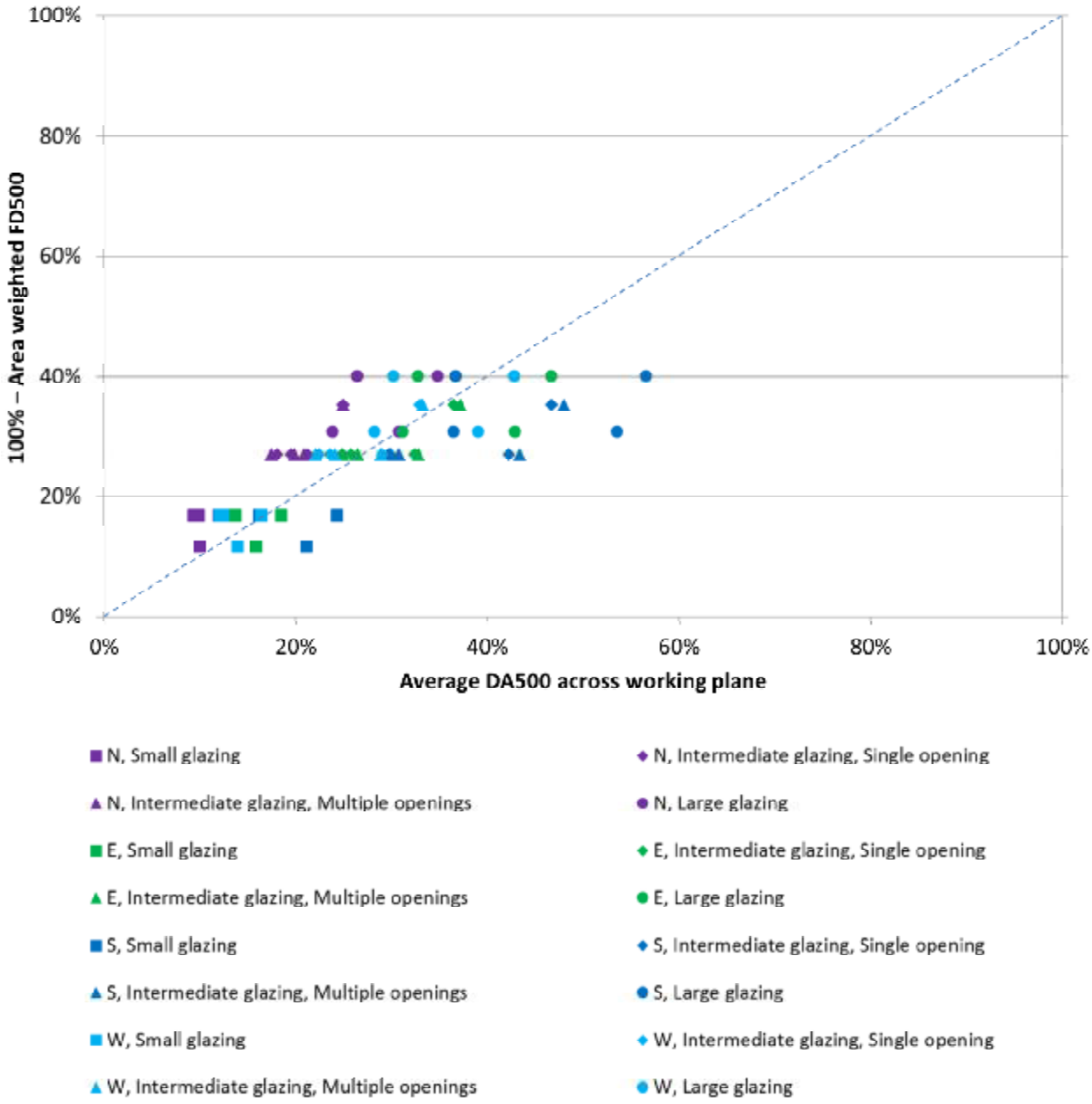


Figure 6.15 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy DA500 for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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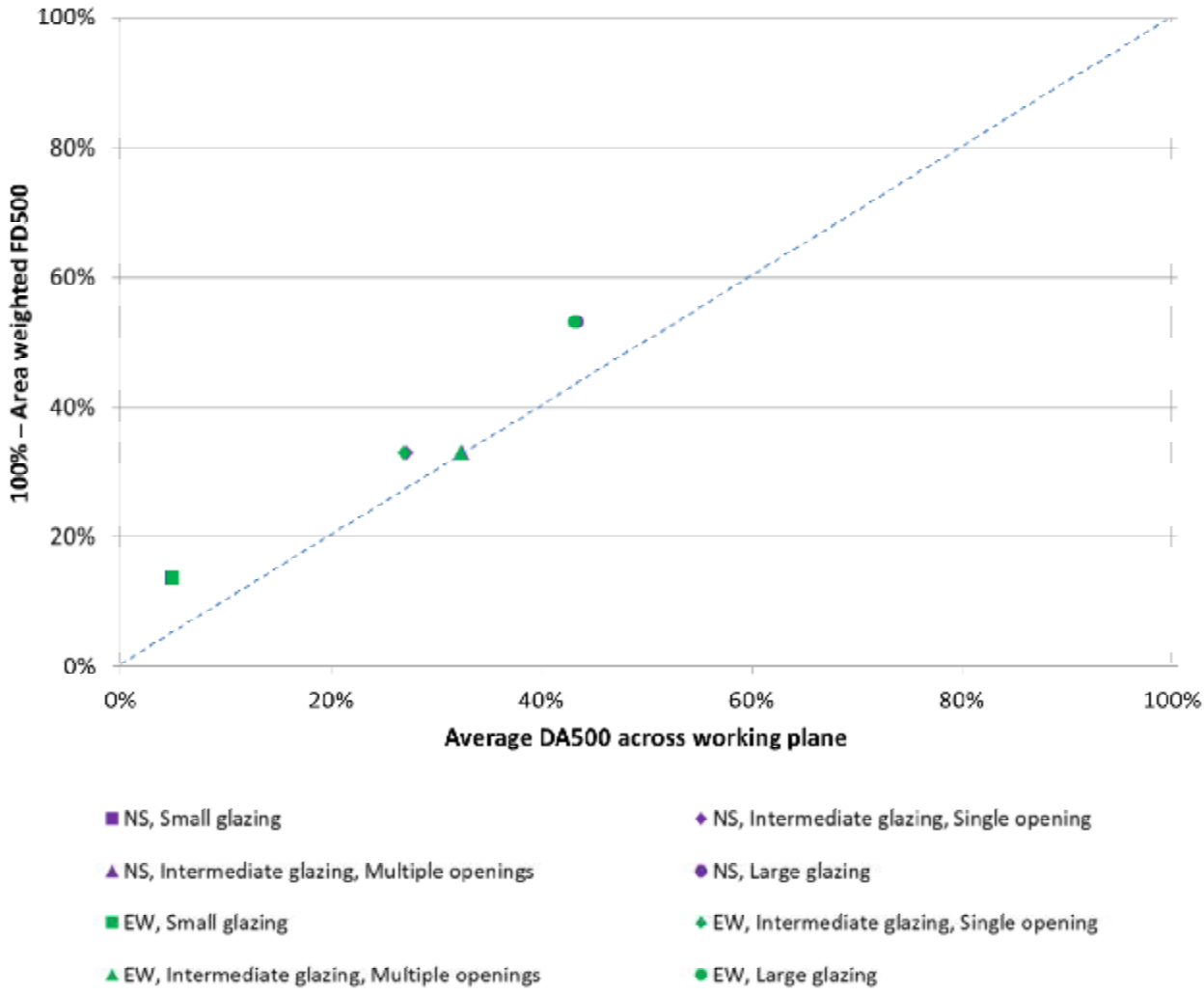


Figure 6.16 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy DA500 for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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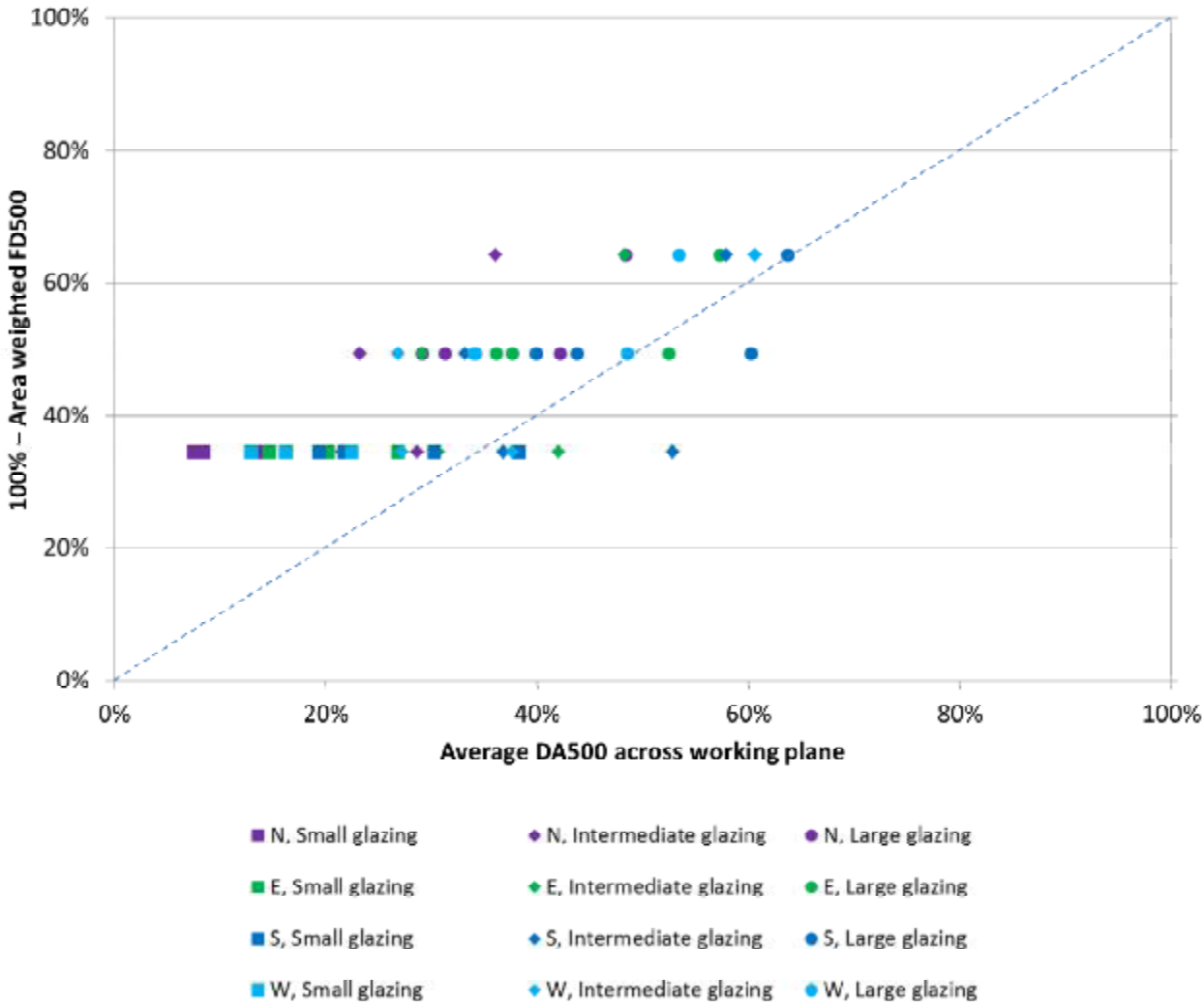


Figure 6.17 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy DA500 for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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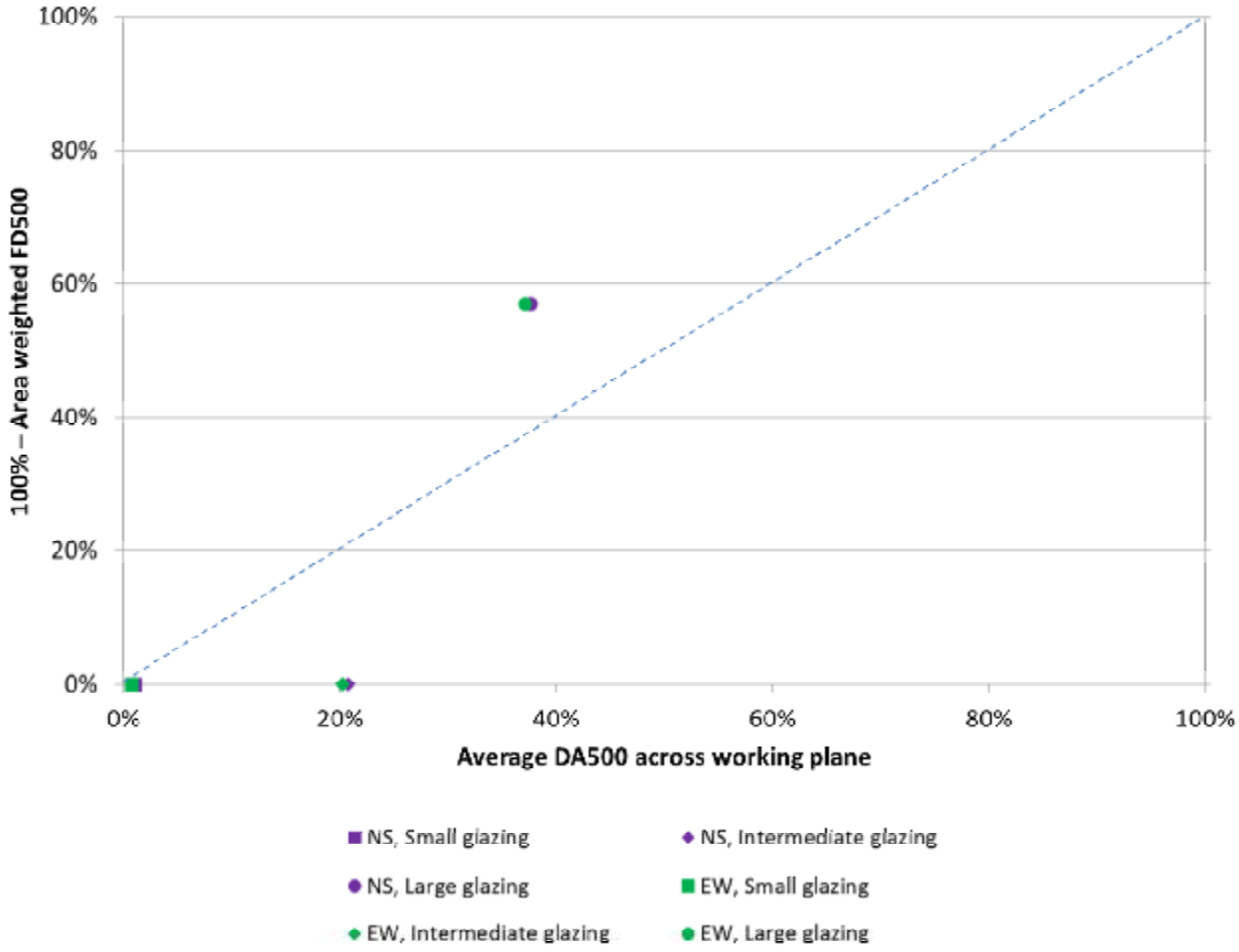


Figure 6.18 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy DA500 for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

Figures 6.15 to 6.18 compare the average daylight autonomy over the whole space with the daylight dependency factor used to generate the LENI in the current EN15193 standard. This could be an appropriate comparison for rooms where each luminaire is switched off when the daylight underneath it is 500 lux (for example where every luminaire has its own integral photocell). It appears that the EN 15193 method generally underestimates daylight availability (based on DA500) in large side-lit rooms and generally overestimates it in small rooms. The reverse applies for the top-lit rooms.

Daylight availability as estimated by the EN15193 method varies in steps, whilst daylight availability as expressed by DA500 varies progressively with glazing area and orientation. Also, the method used in the current EN15193 does not consider any variation in daylight availability with glazing orientation.

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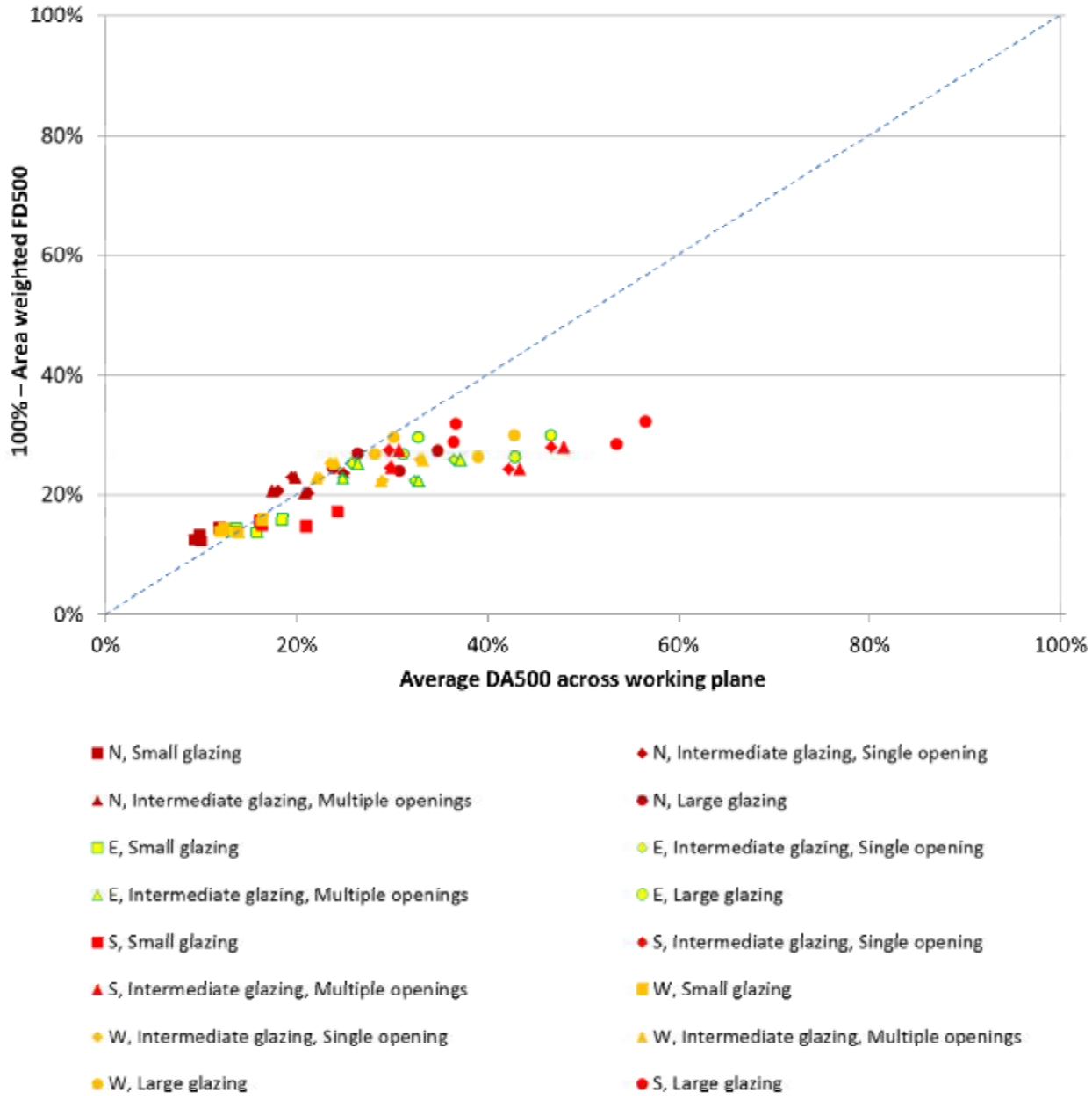


Figure 6.19 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy DA500 for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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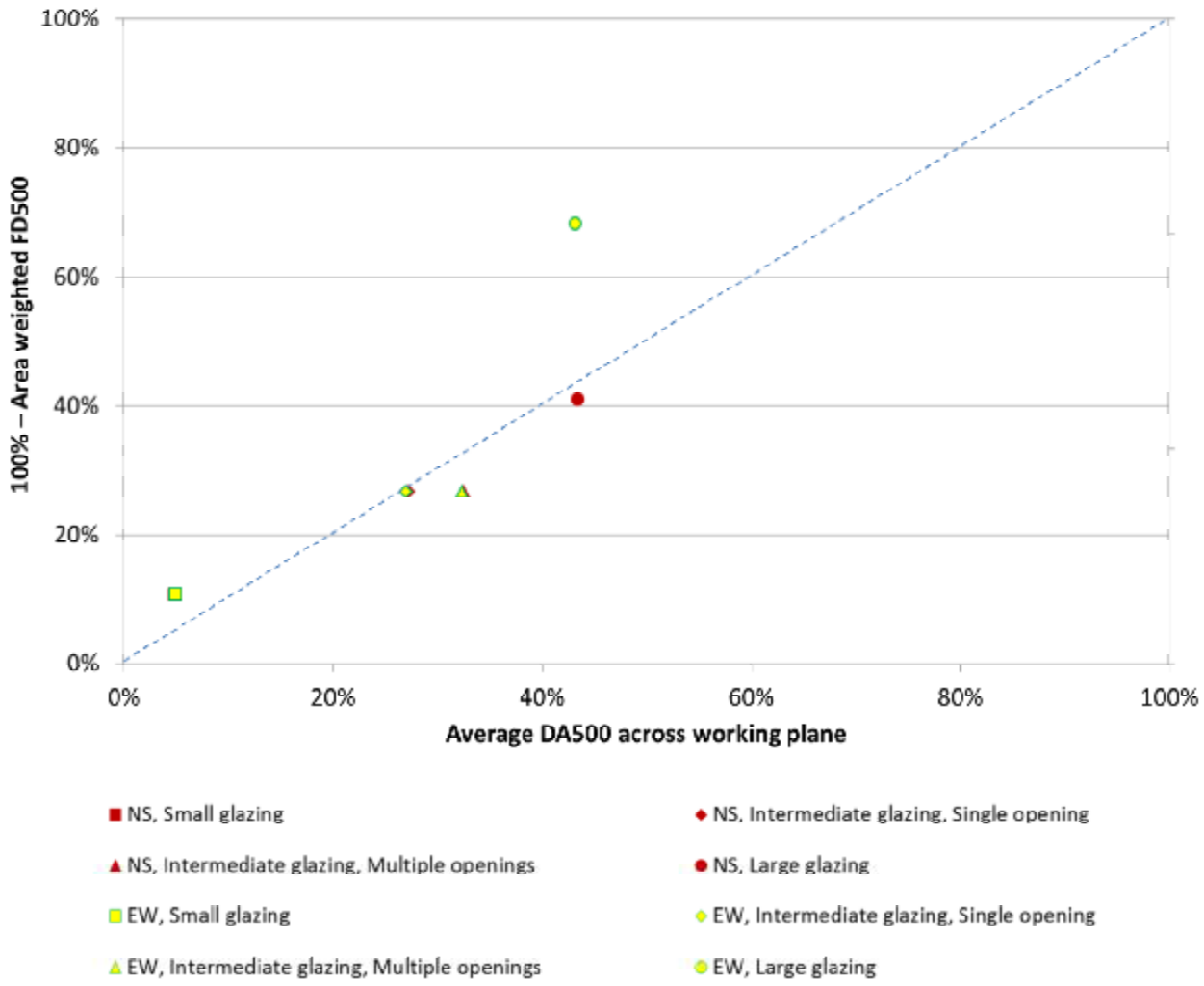


Figure 6.20 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy DA500 for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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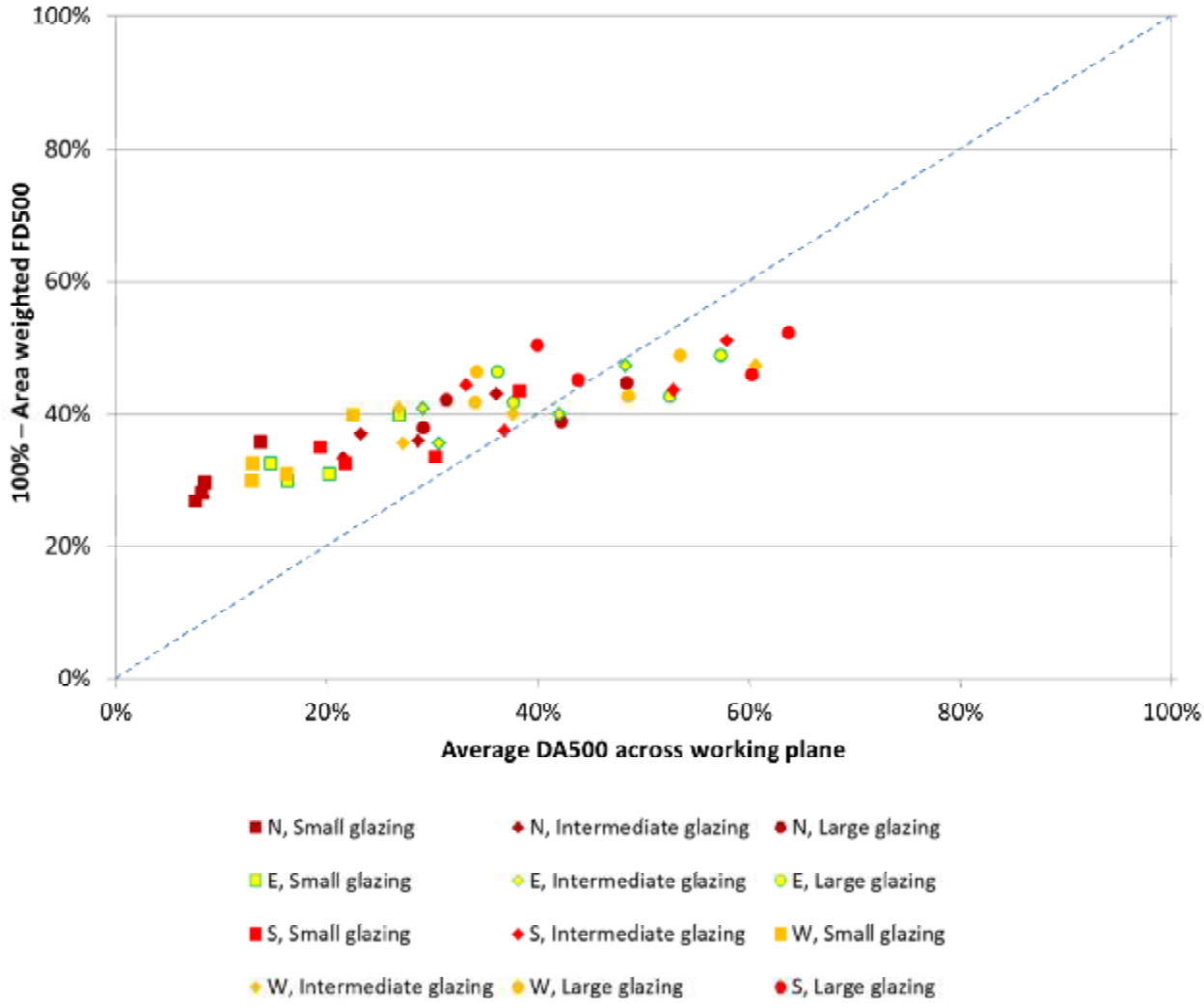


Figure 6.21 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy DA500 for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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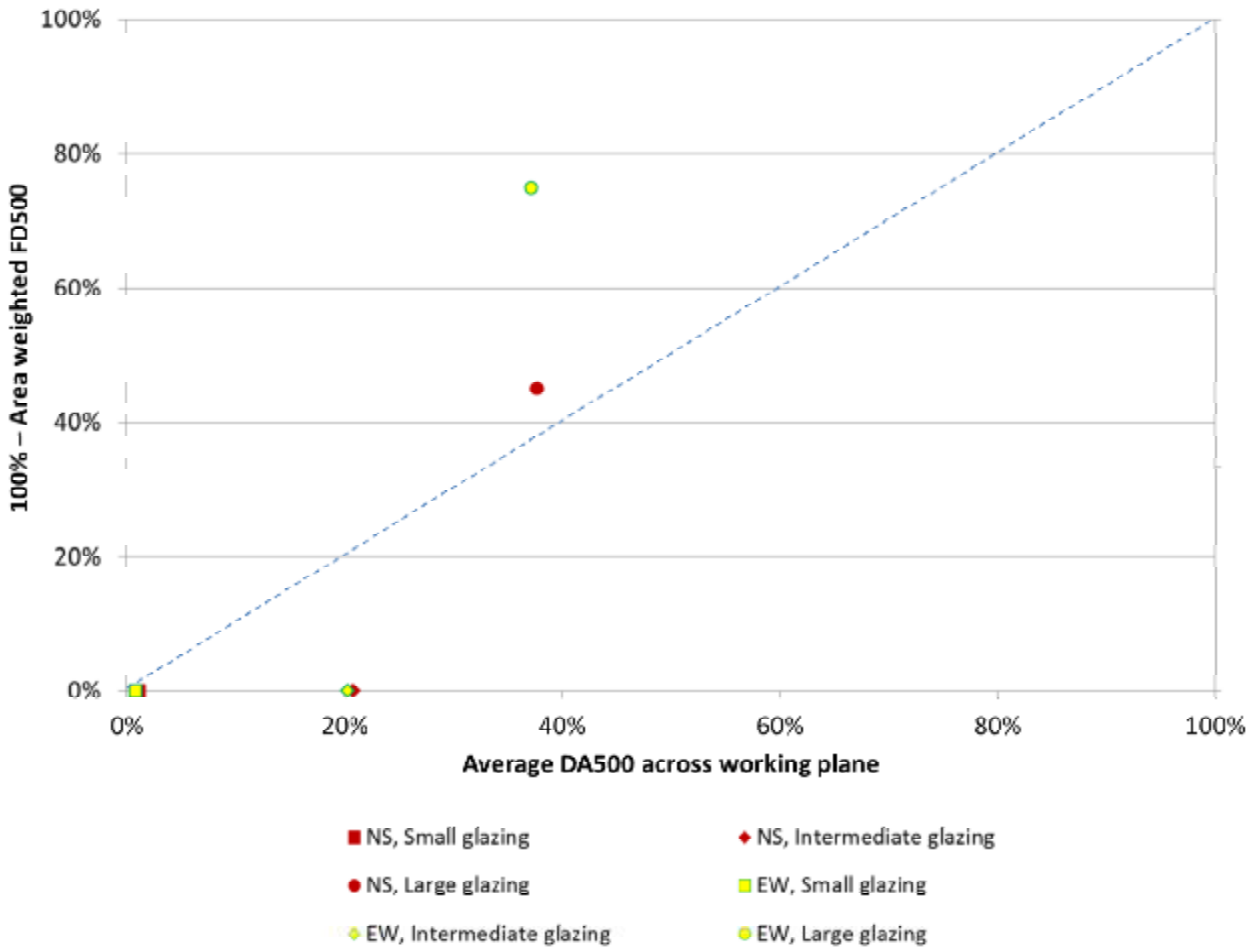


Figure 6.22 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy DA500 for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

Figures 6.19 to 6.22 present the same analysis, but the daylight dependency calculation is based on the proposed revision to the EN15193 standard. The findings that can be inferred from Figures 6.19 to 6.22 are more or less similar to those from Figures 6.15 to 6.18. However, in contrast with the method used in the current EN15193, the proposed revision introduces changes in daylight availability with façade orientation, which is in line with the method based on daylight autonomy.

For side lit rooms, the EN15193 method tends to overestimate savings from daylight in spaces with less light, and to underestimate in spaces with more light. This is likely to arise from the formulation of the daylight dependency calculation. The daylight dependency may include savings from when daylight is present but is lower than the switching illuminance. This would give better results with dimming controls, but overestimate the savings from switching controls in spaces with less light.

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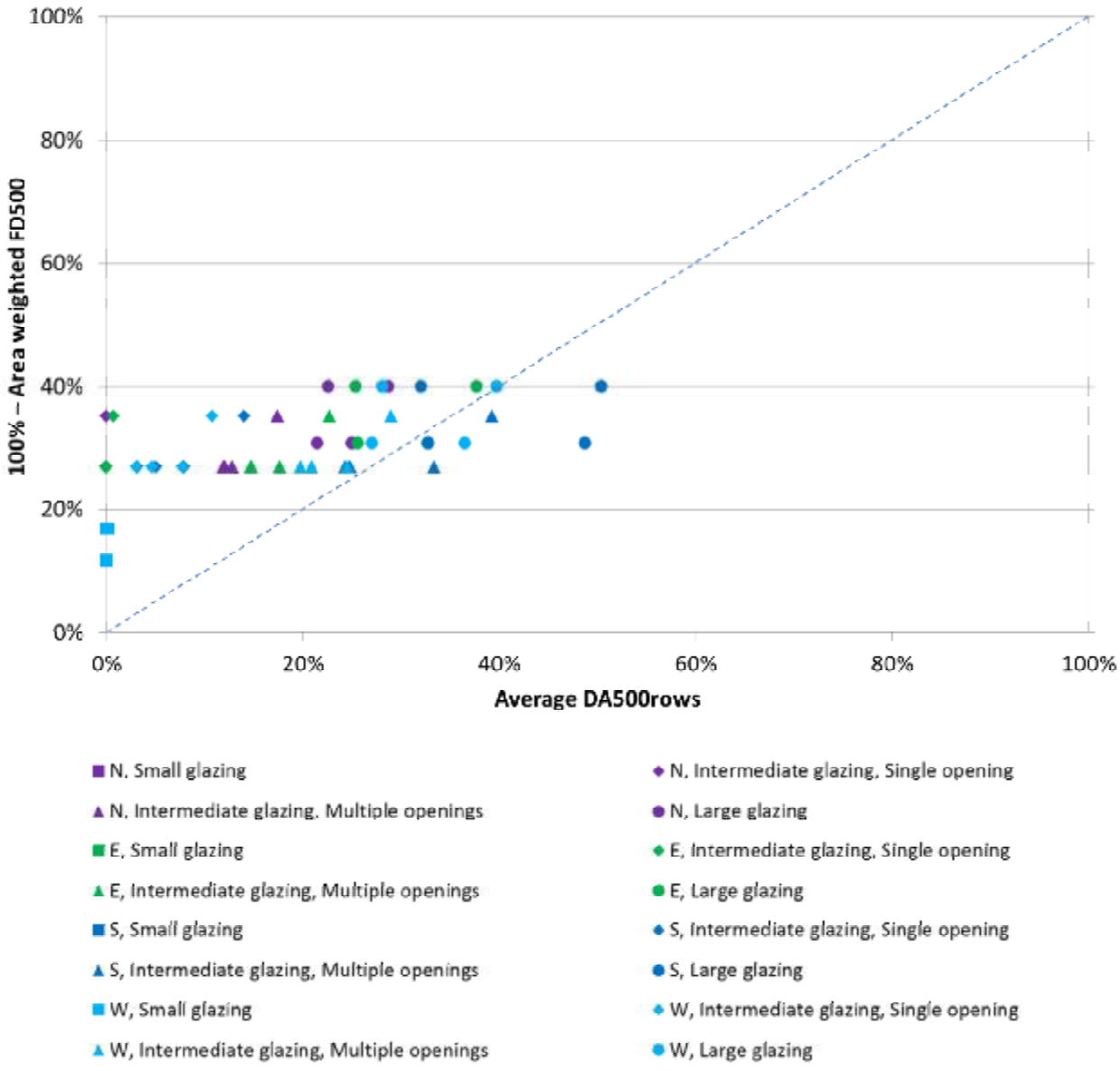


Figure 6.23 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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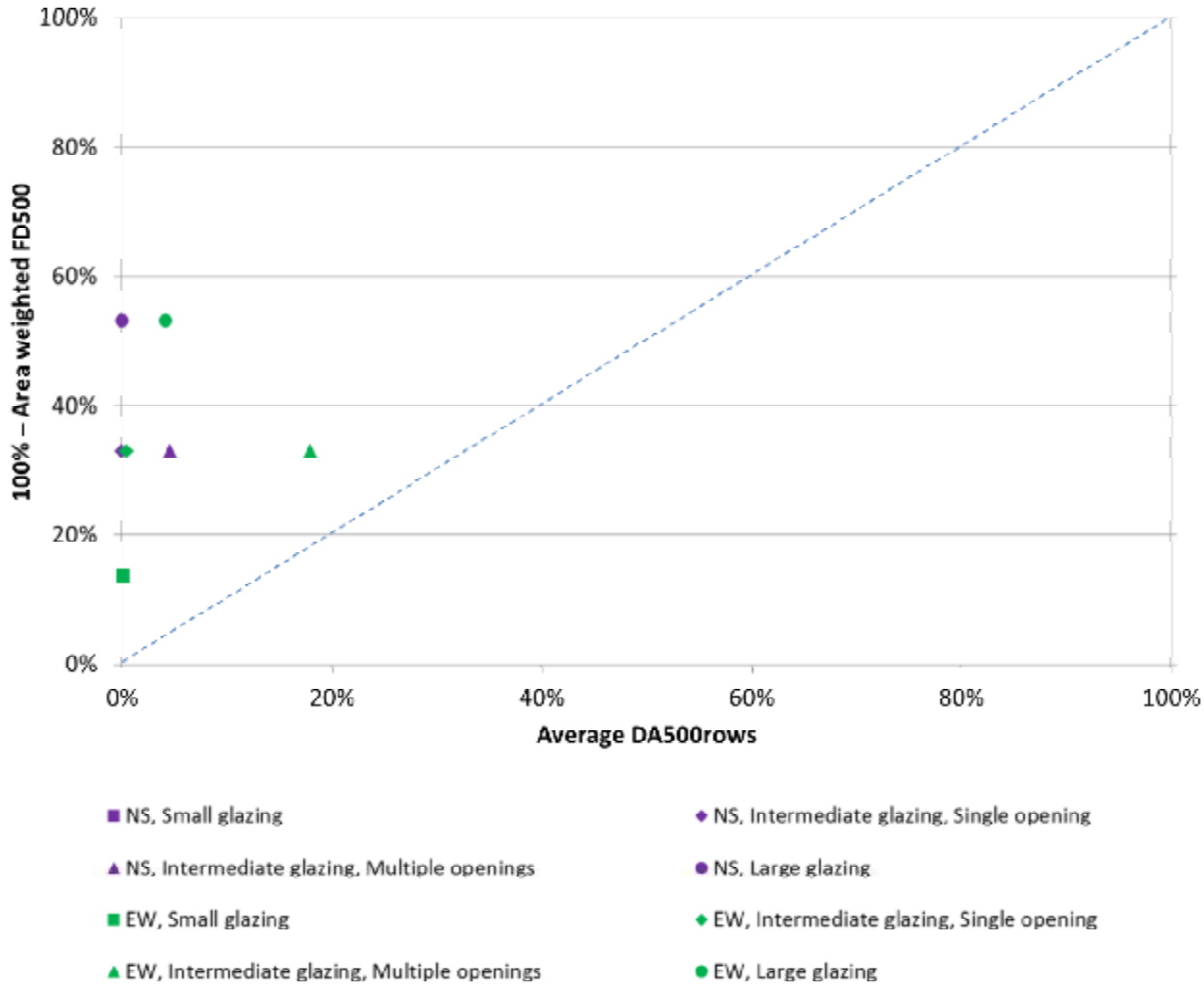


Figure 6.24 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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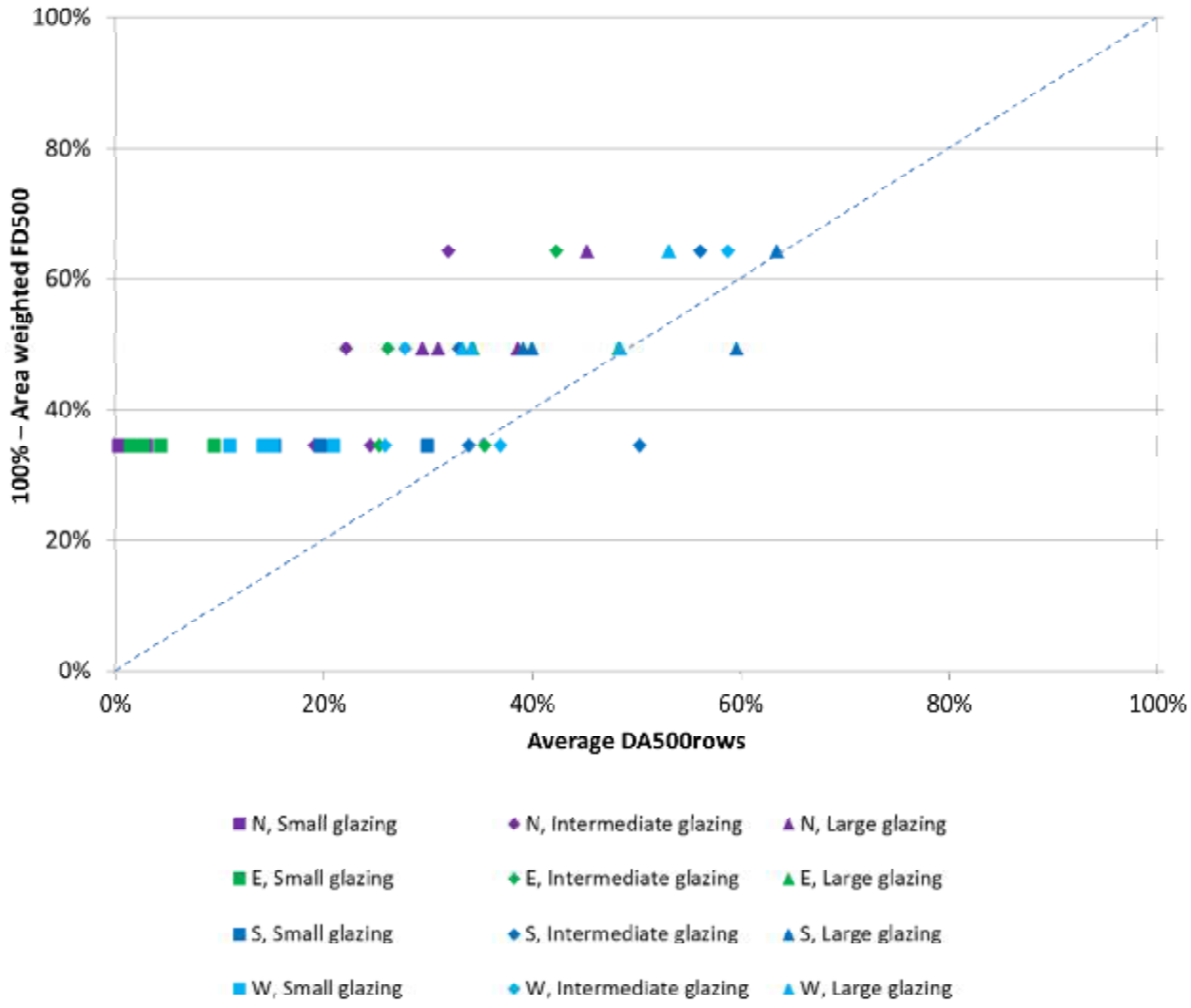


Figure 6.25 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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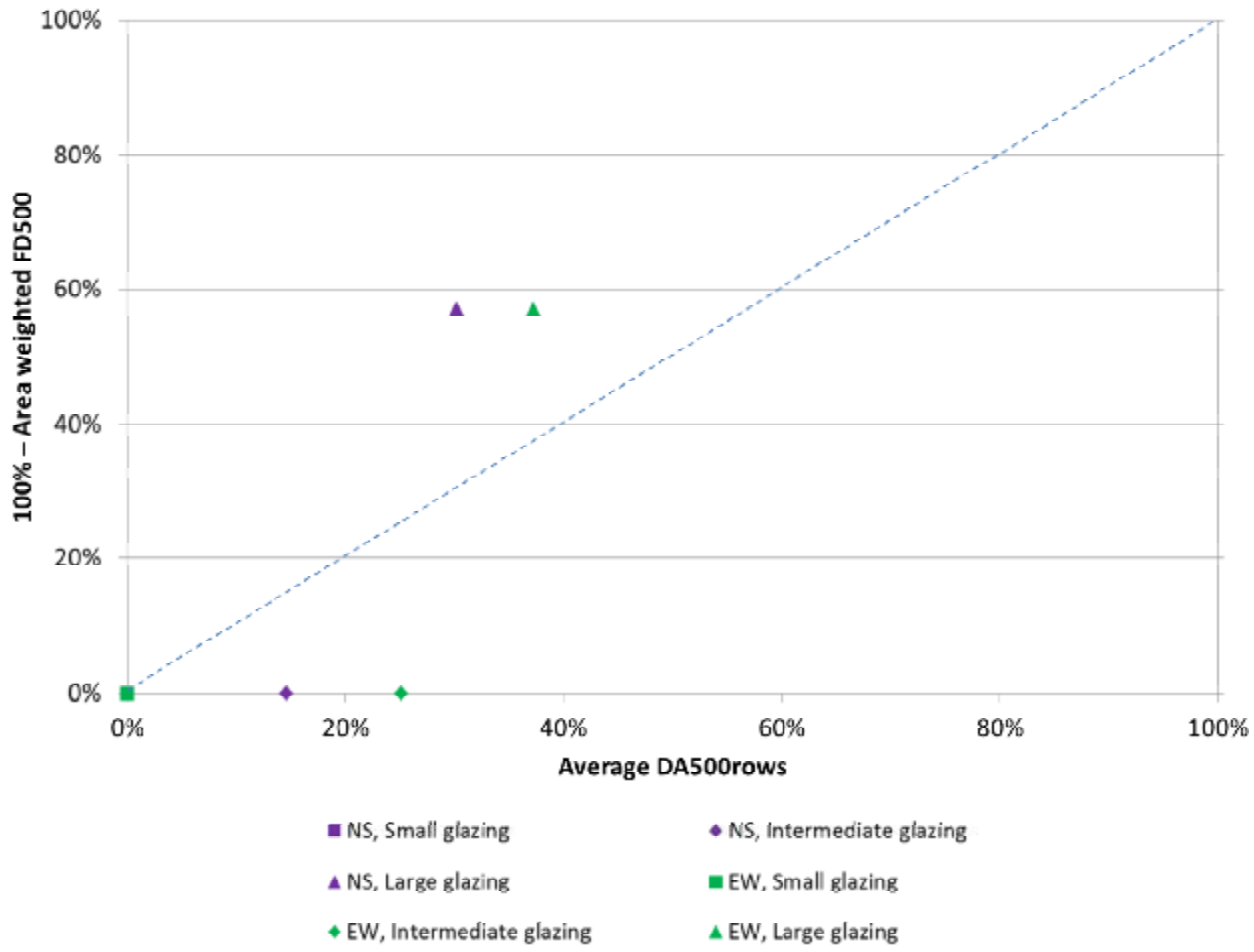


Figure 6.26 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the current EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

Figures 6.23-6.26 compare the daylight dependency factor in the current EN15193 with the average daylight autonomy at the ends of the luminaire rows. This is an appropriate comparison for automatic control where each row of luminaires is switched off when the illuminance beneath the luminaires is at least 500 lux at the worst lit point (a commoner means of control than switching every luminaire separately). The EN 15193 method tends to overestimate the savings due to daylight, and underestimate electric lighting use for such an installation.

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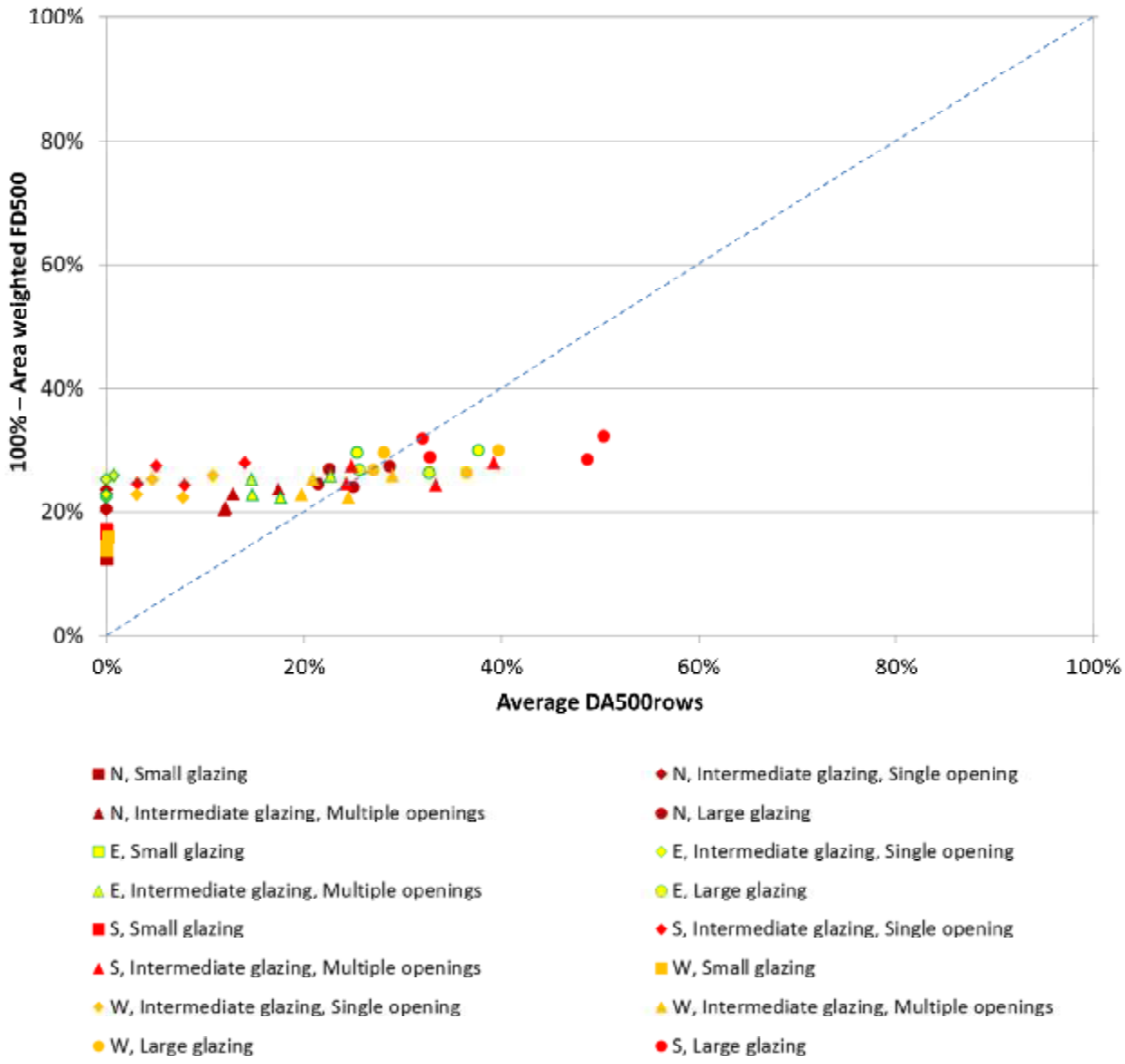


Figure 6.27 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for large side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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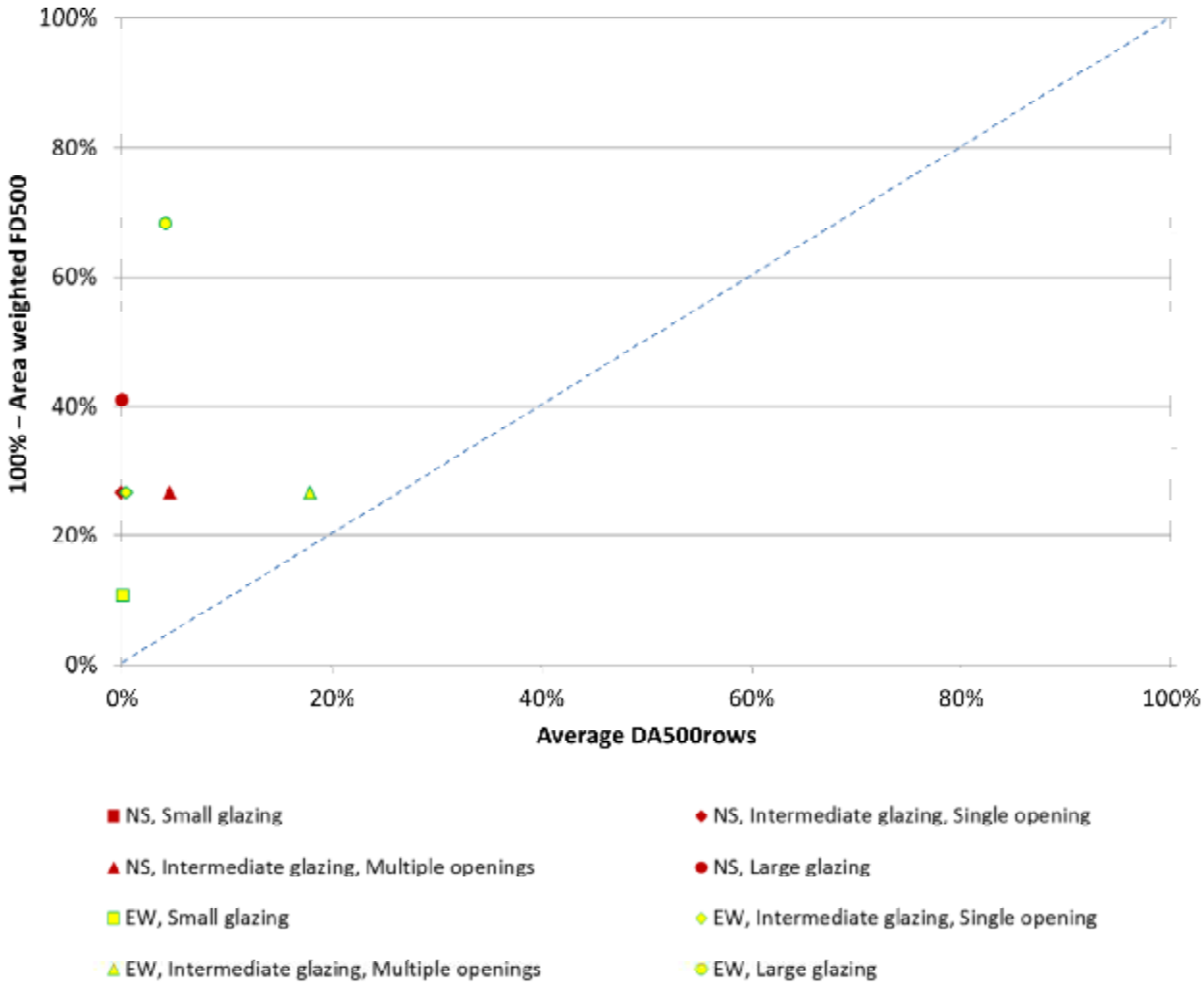


Figure 6.28 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for large top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

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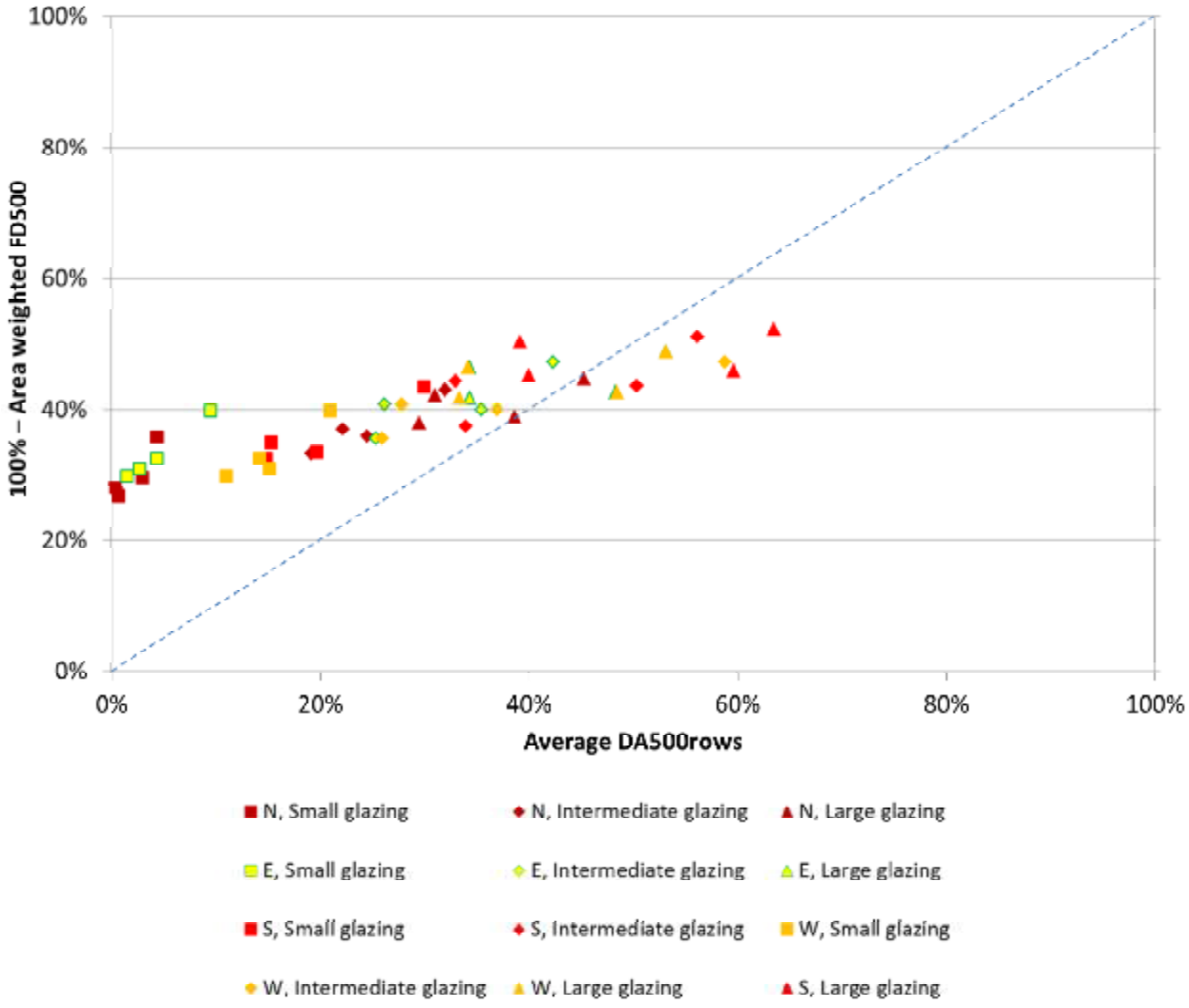


Figure 6.29 100% – area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for small side-lit room used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations.

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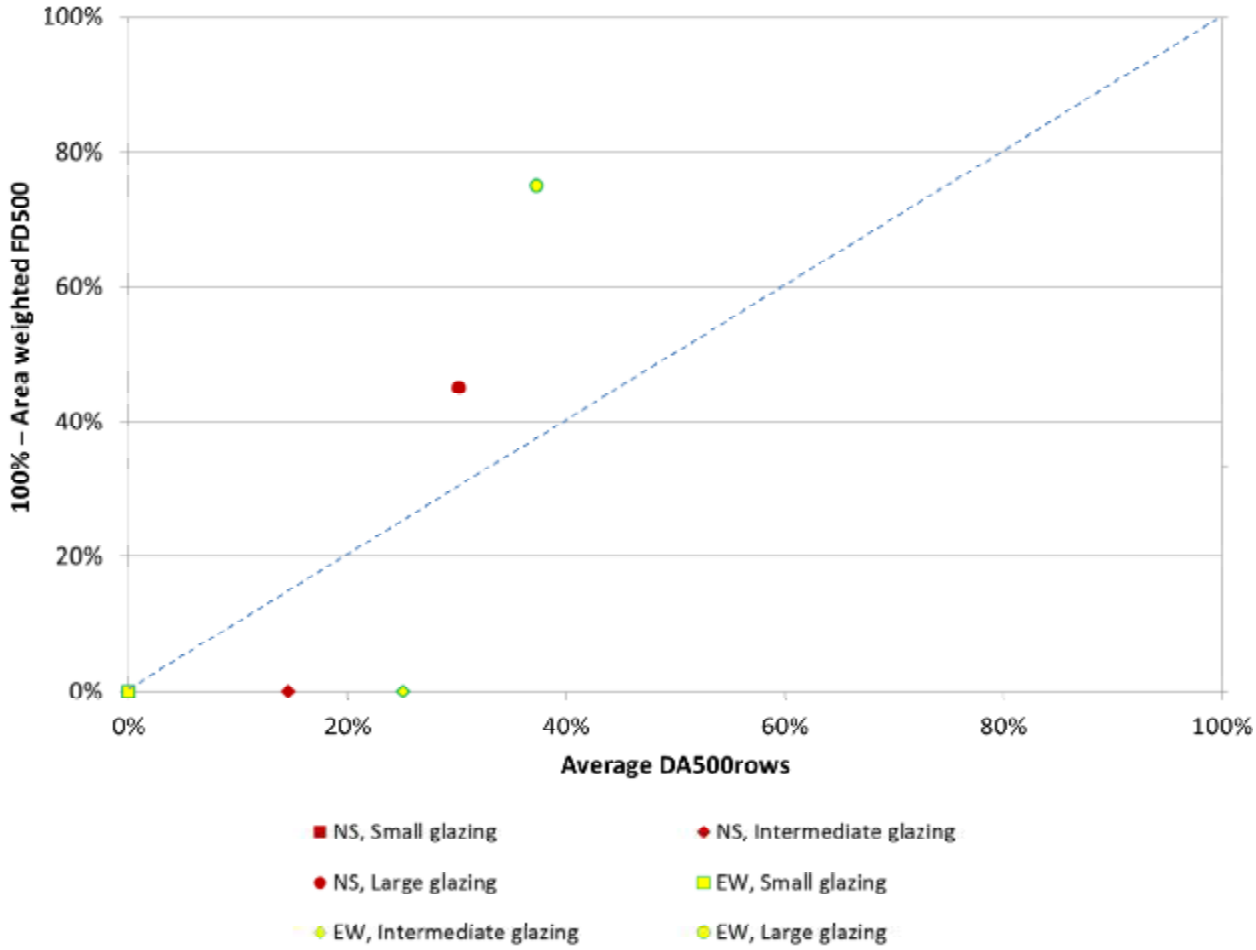


Figure 6.30 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage and calculated using the newly proposed EN15193 standard) versus average daylight autonomy at luminaire row ends DA500rows for small top-lit room used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations.

Figures 6.27 to 6.30 show the same analysis for the proposed revision of EN15193. It introduces a progressive variation of daylight availability with façade orientation and glazing area, whilst the current method leads to a stepped variation.

However, by considering daylight availability as expressed through DA500 at the ends of luminaire rows, which is what one would expect to be achieved in real applications, the method used by both the current and the newly proposed EN15193 overestimates daylight penetration in the majority of cases, and consequently this leads to an underestimation of the energy used for electric lighting.

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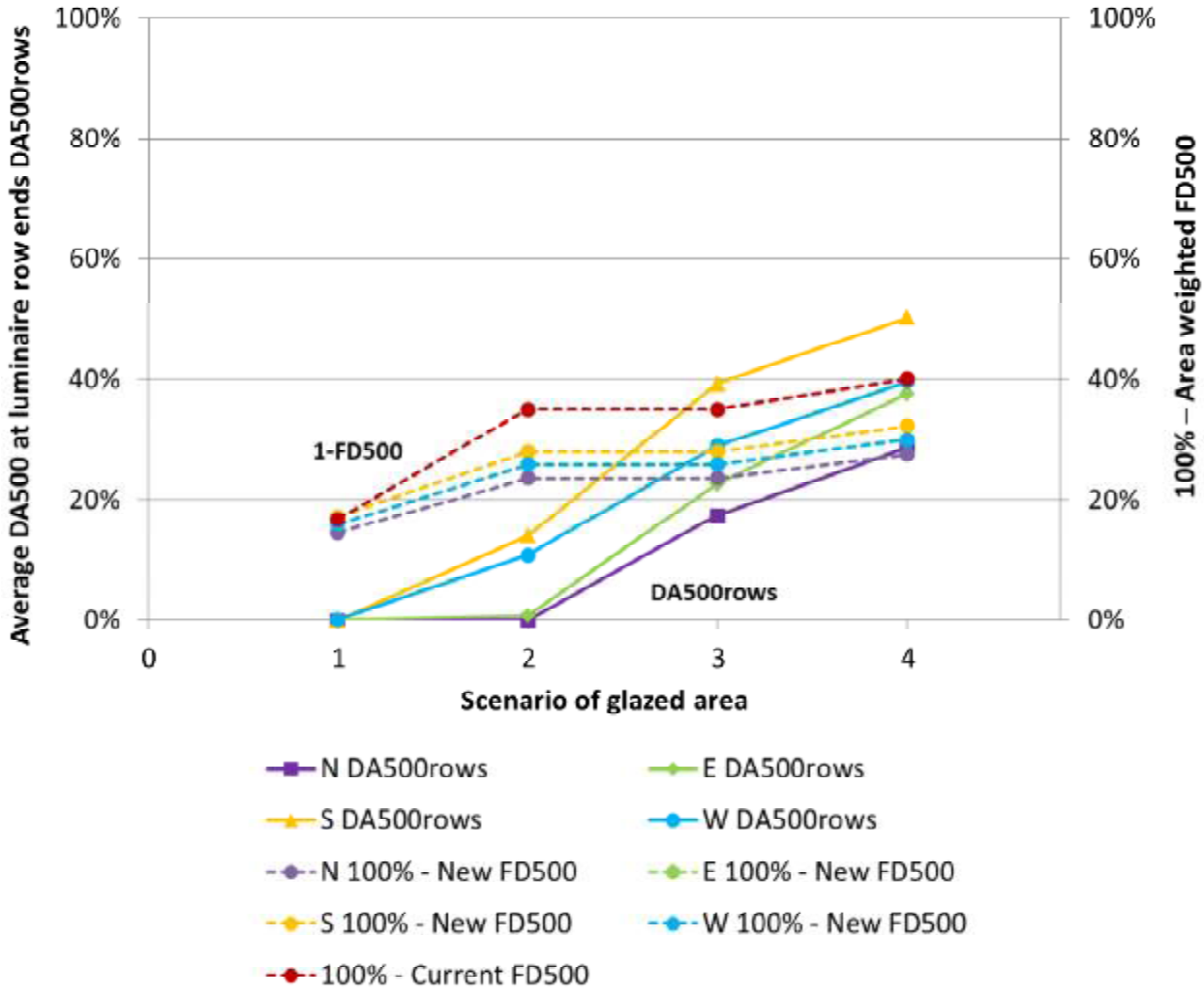


Figure 6.31 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for large side-lit room with no external obstructions and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area, single opening; 3 – Intermediate glazed area, multiple openings; 4 – Large glazed area.

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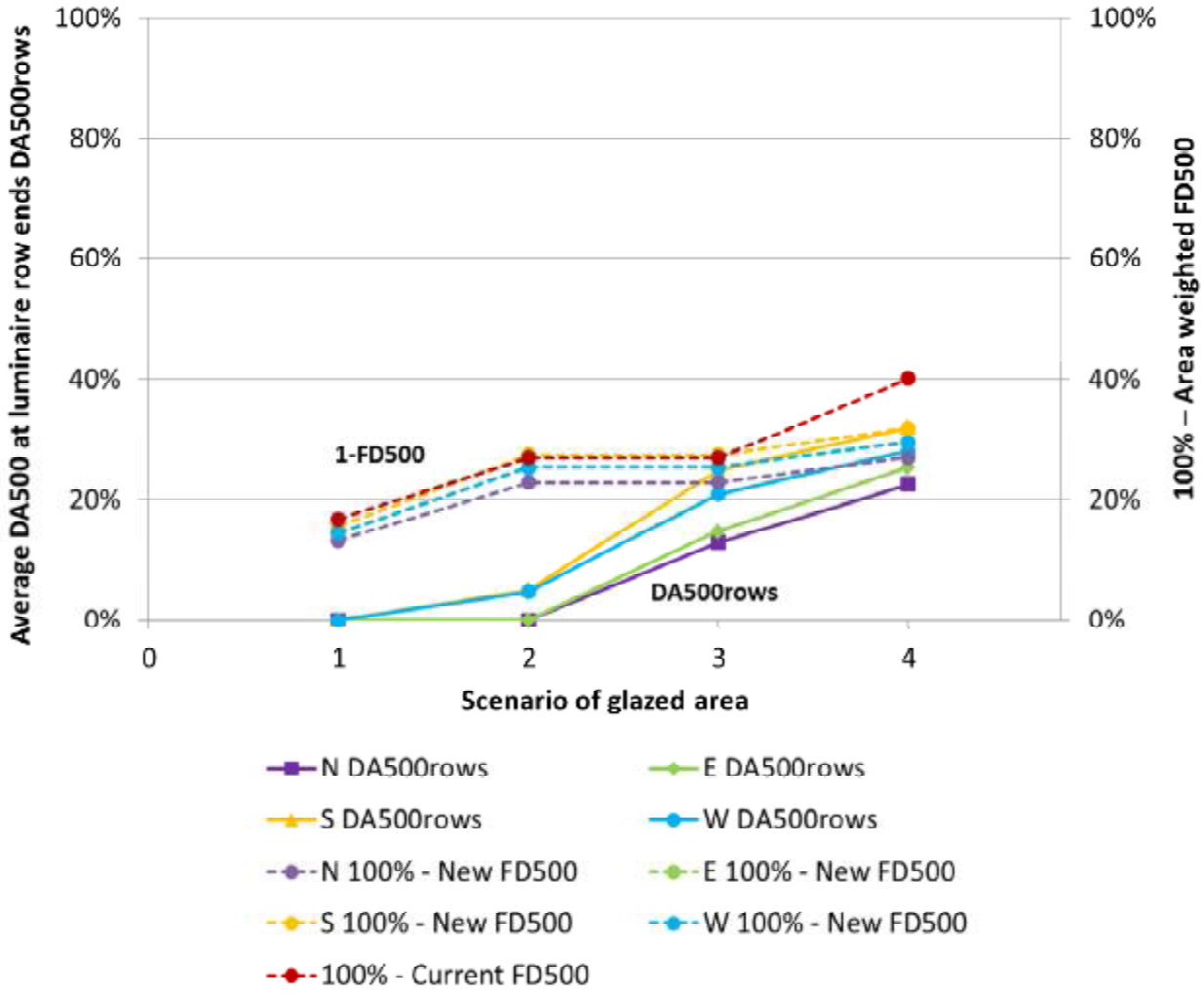


Figure 6.32 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for large side-lit room with linear external obstruction and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area, single opening; 3 – Intermediate glazed area, multiple openings; 4 – Large glazed area.

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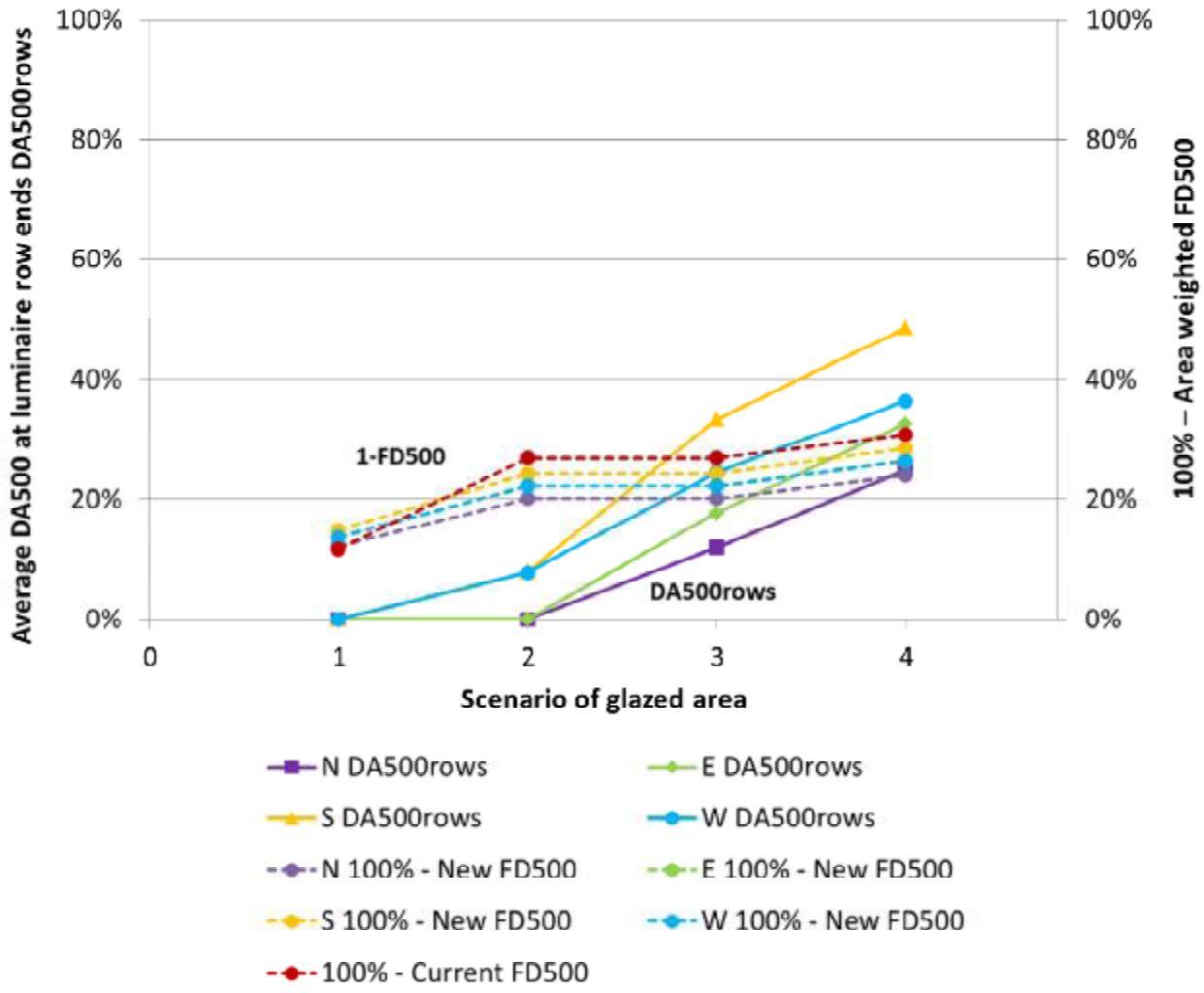


Figure 6.33 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for large side-lit room with overhang and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area, single opening; 3 – Intermediate glazed area, multiple openings; 4 – Large glazed area.

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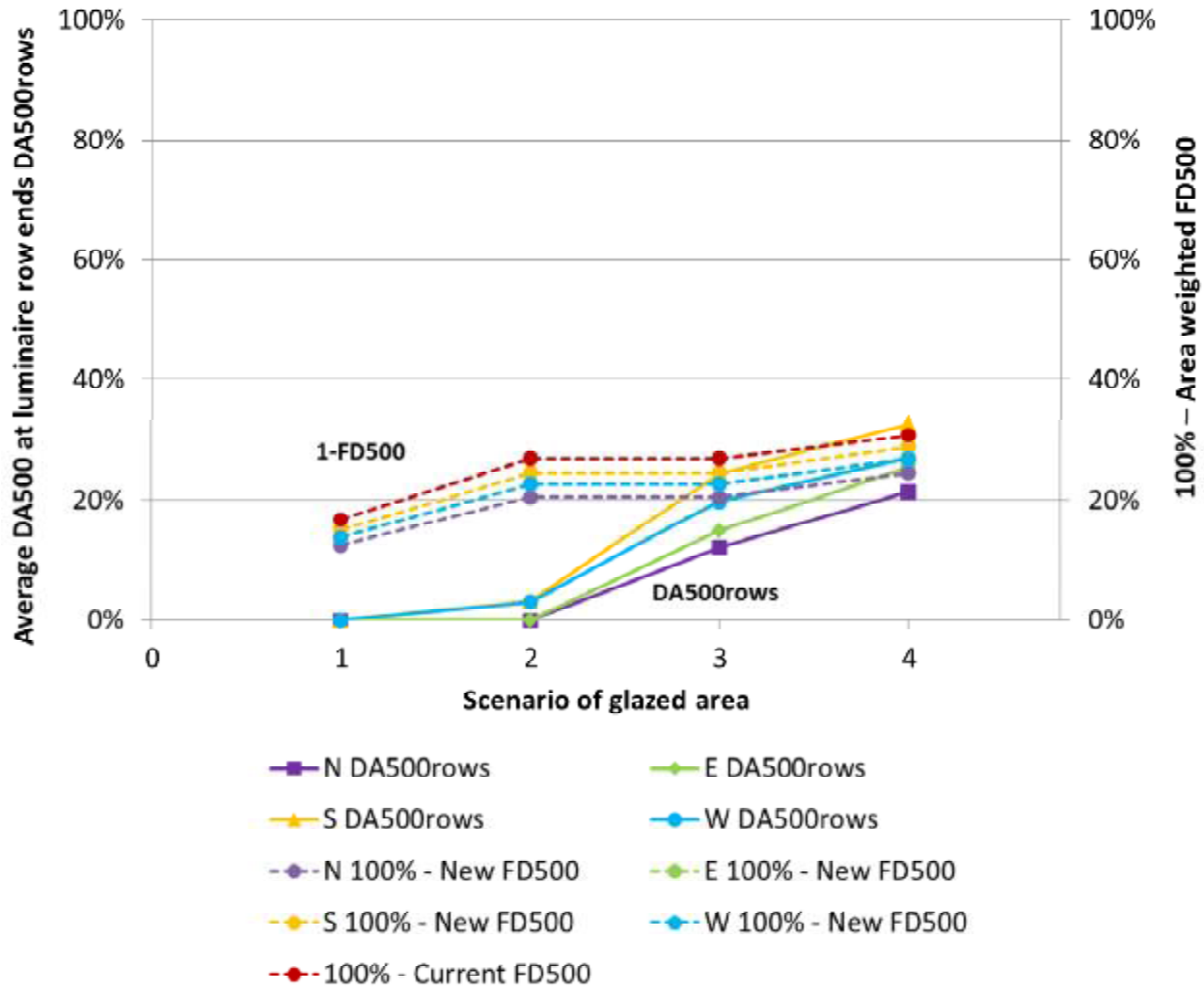


Figure 6.34 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for large side-lit room placed inside courtyard and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area, single opening; 3 – Intermediate glazed area, multiple openings; 4 – Large glazed area.

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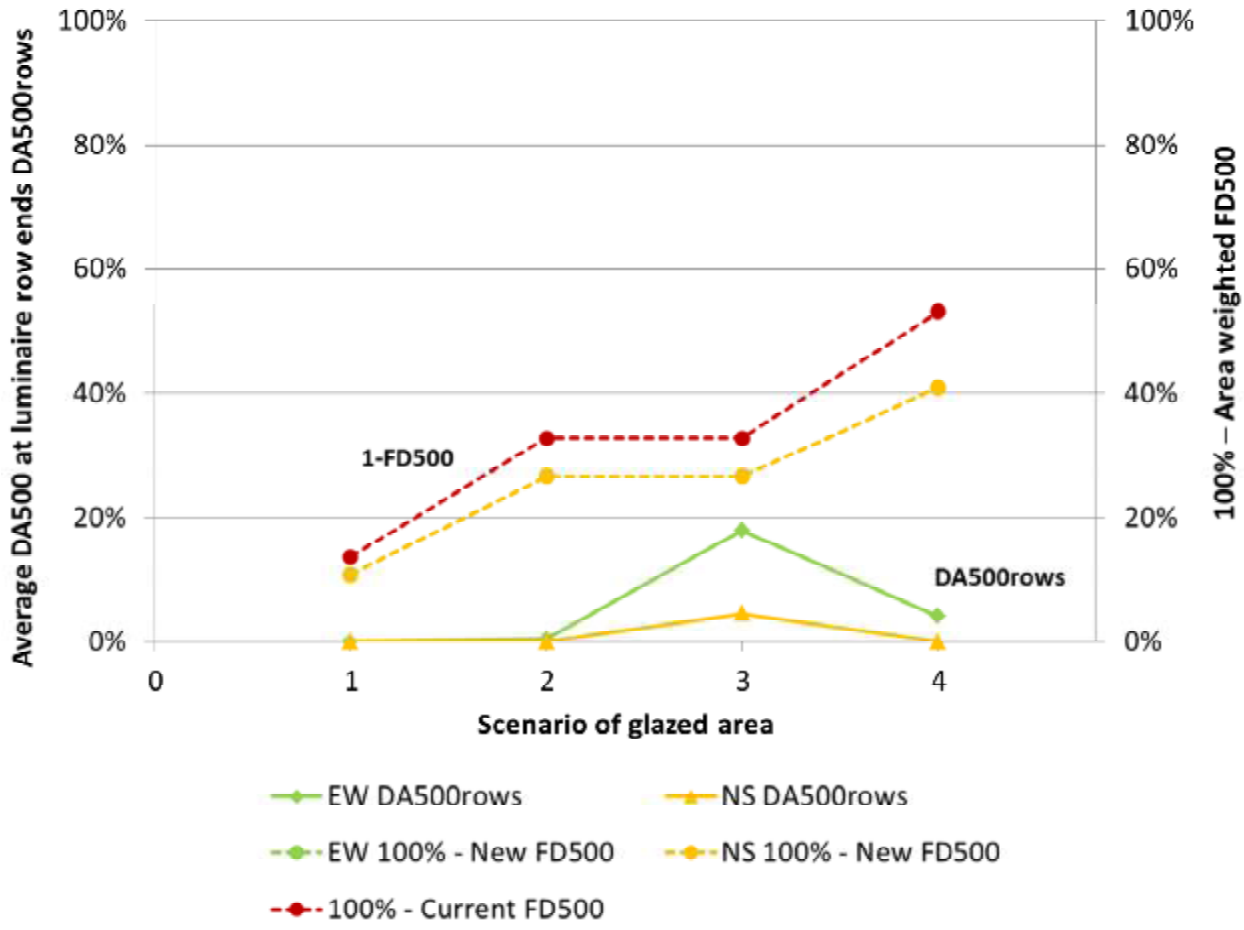


Figure 6.35 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for large top-lit room with no external obstructions and used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area, single opening; 3 – Intermediate glazed area, multiple openings; 4 – Large glazed area.

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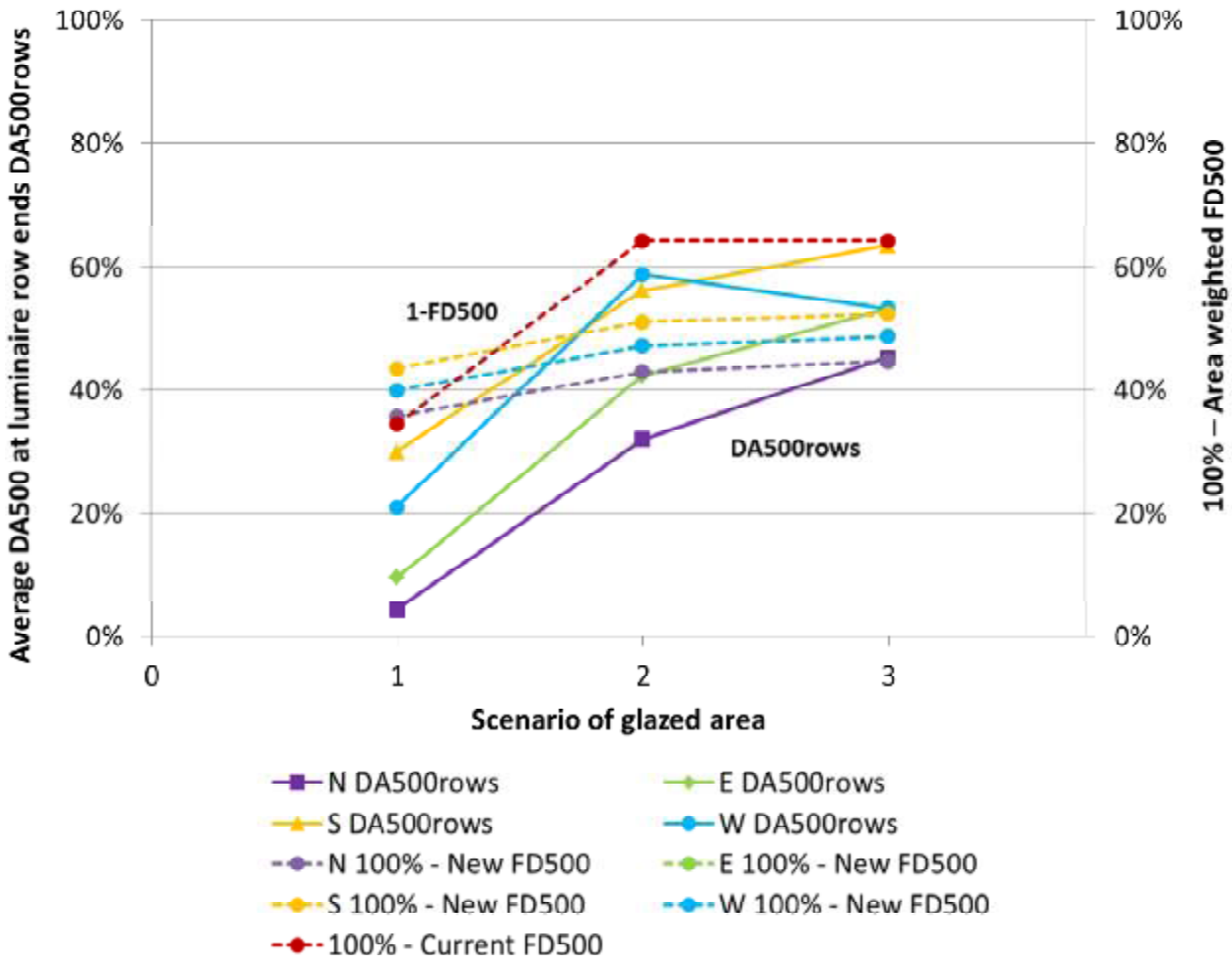


Figure 6.36 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for small side-lit room with no external obstructions and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area; 3 – Large glazed area.

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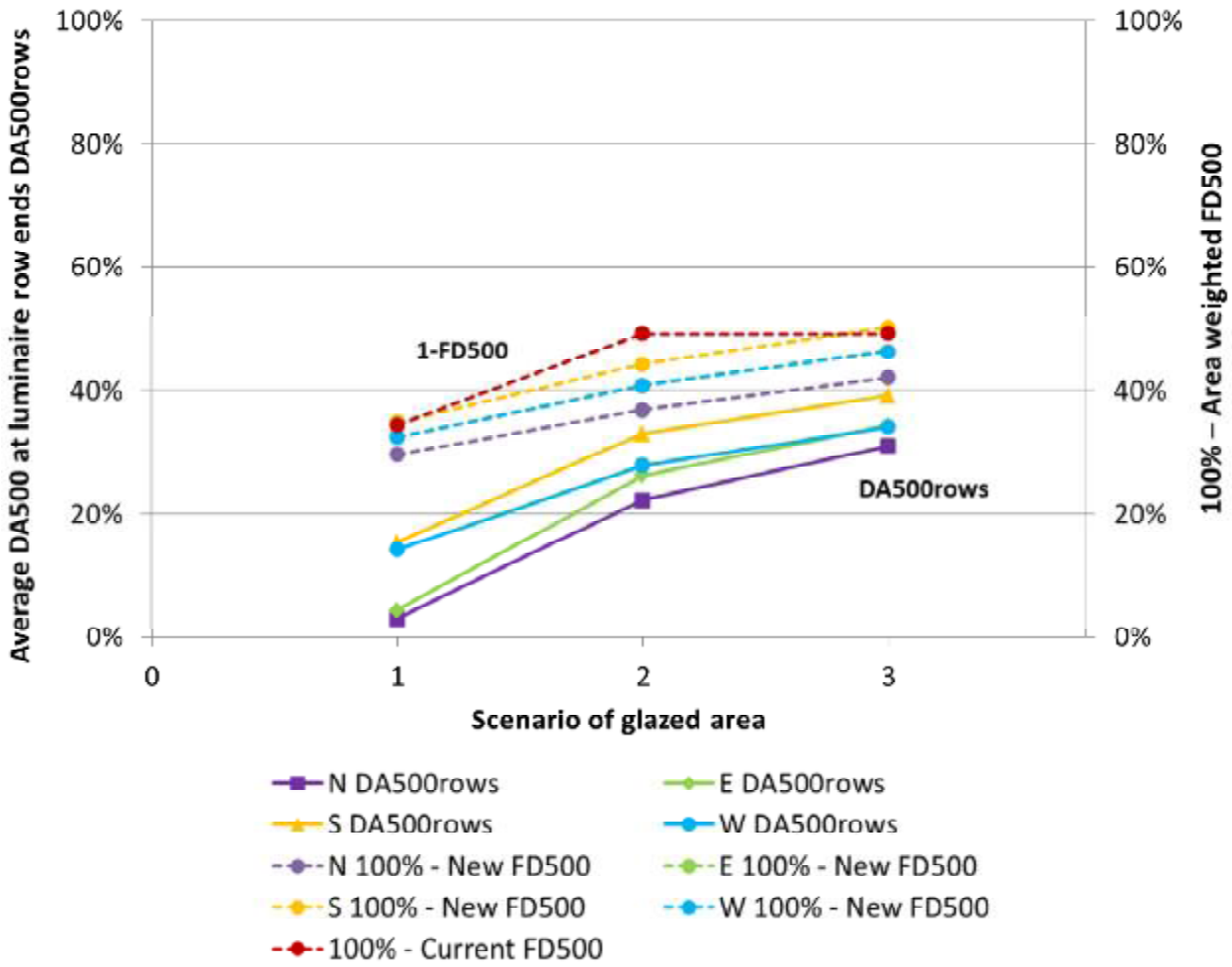


Figure 6.37 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for small side-lit room with linear external obstruction and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area; 3 – Large glazed area.

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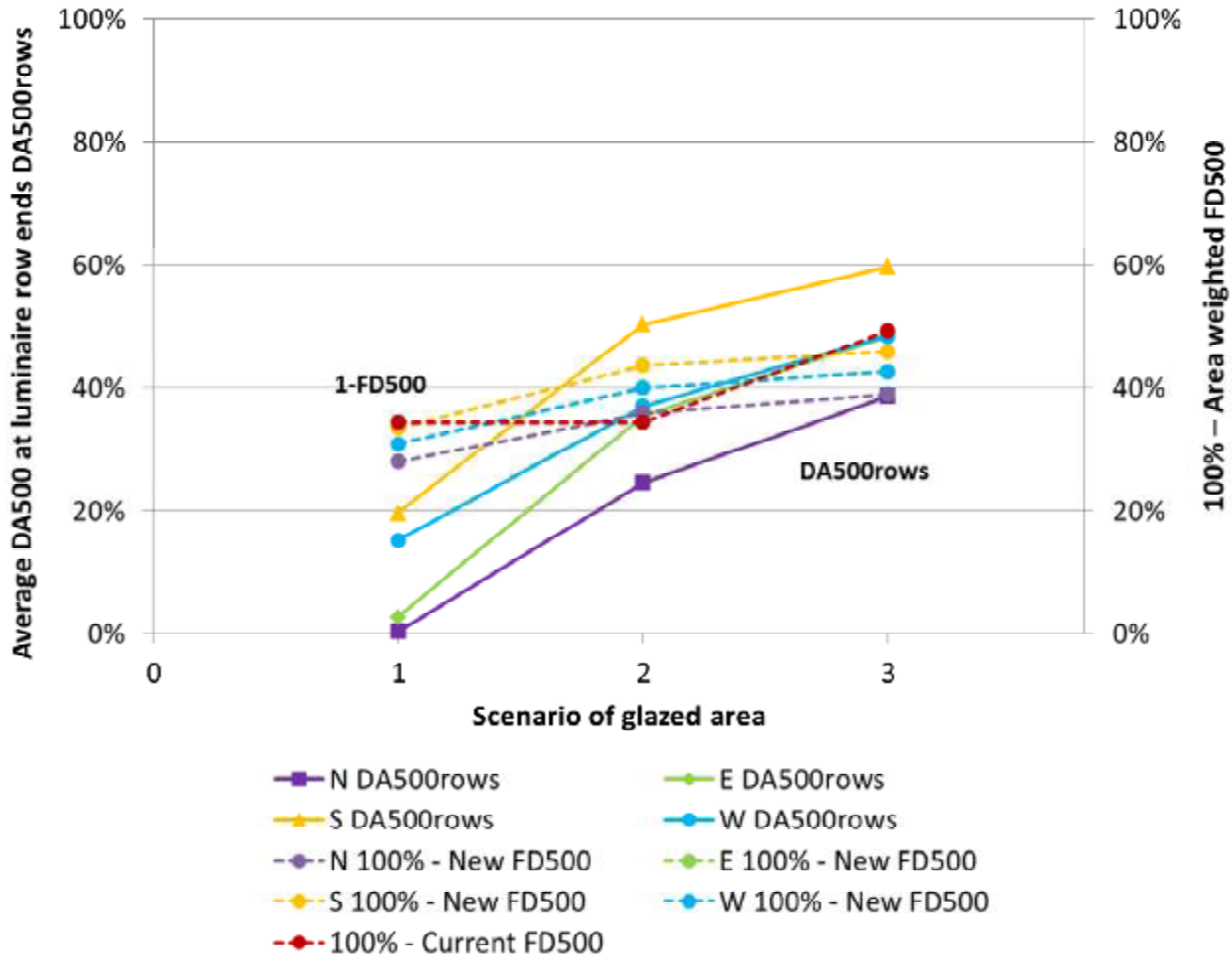


Figure 6.38 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for small side-lit room with overhang and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area; 3 – Large glazed area.

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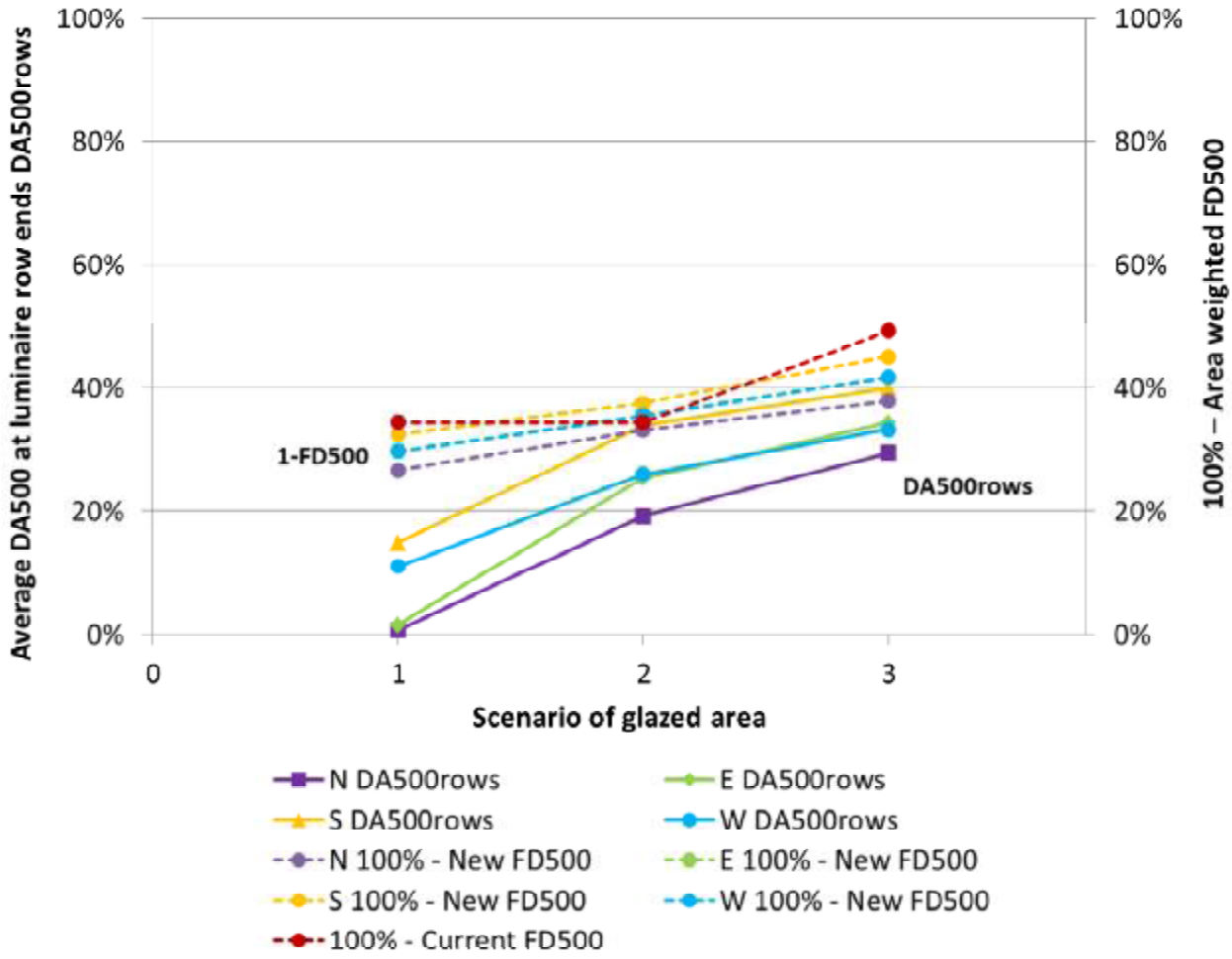


Figure 6.39 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for small side-lit room placed inside courtyard and used as an office with working hours from 8.30 to 17.30. Symbols N, E, S and W indicate window orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area; 3 – Large glazed area.

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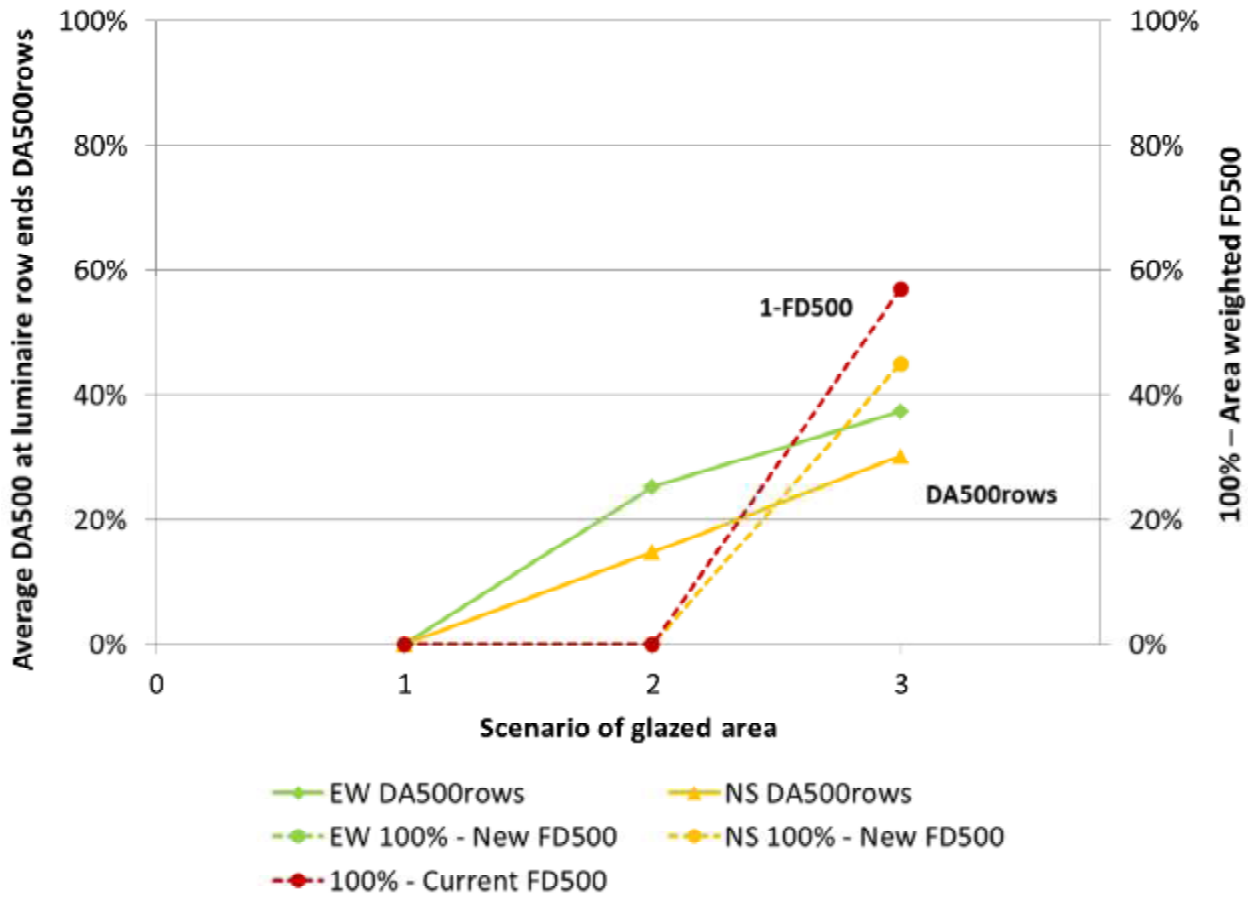


Figure 6.40 Average daylight autonomy at luminaire row ends DA500rows and 100% ─ area weighted daylight dependency factor FD500 (expressed as a percentage) for small top-lit room with no external obstructions and used as an office with working hours from 8.30 to 17.30. Symbols NS and EW indicate rooflight orientations. Horizontal axis shows glazed area scenarios as follows: 1 – Small glazed area; 2 – Intermediate glazed area; 3 – Large glazed area.

Figures 6.31 to 6.40 show that in general the methods used both in the current and in the newly proposed EN15193 predict higher daylight penetration in both large and small rooms compared with the DA based method. There are some exceptions, such as large and small side-lit rooms with no linear obstruction or with overhang and having larger glazing facing south, east or west. The same also applies to small top-lit rooms with the largest rooflights.

There are also cases of rooms with small glazing where DA500 at luminaire row ends is zero due to lower daylight penetration. In practice this corresponds with situations where electric lighting is kept on, particularly in non-daylit zones opposite window walls, in response to less incoming daylight. Nevertheless, the EN15193 method tends to overestimate daylight penetration even in such cases. Therefore it could be inferred that lighting energy use may in reality be higher than LENI-based predictions.

In Figure 6.35, DA500 is the highest in scenario 3 due to rooflights being placed closer to the calculation points, whilst in scenario 4, although the rooflight is larger it is positioned farther from most of the calculation points, hence less daylight reaches these points and therefore the average DA is lower.

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7 Conclusions

This report presents an assessment of different metrics to predict daylighting in interiors.

Traditional methods of daylight design rely on the daylight factor. This is the ratio of the daylight indoors to that on an unobstructed horizontal plane outdoors, under a standard overcast sky. The daylight factor is easy to calculate and it is a constant which depends only on the building. This makes it easy to use and apply as a design criterion. However it does not take account of the variations of daylight under sunny skies and does not vary with orientation. The daylight factor is therefore a poor metric to use in parts of the world where overcast skies are rare, or if there are special features such as light shelves, reflectors or prismatic glazing which make use of redirected sunlight.

Lighting use in daylit interiors depends on the type of control system as well as on the level of daylight provision. Lighting use can be calculated using a variety of methods, some of which are based on the daylight factor. They may include corrections for orientation and non-overcast skies.

The LENI is a method for predicting lighting energy use. It relies on equations given in EN15193 'Energy performance of buildings-Energy requirements for lighting' to predict daylight factors and the resulting lighting use for different control strategies. In this report, calculations from these equations were compared with the results of daylight modelling in example rooms. The analysis revealed various issues with the calculations in EN15193:

- The method of dividing the rooms into daylit and non-daylit zones can give artificial boundaries in some cases, which are unlikely to reflect the way electric lighting is controlled in practice.
- In the current EN15193, LENI values, being based on daylight factors, do not vary with orientation. This is proposed to be corrected in a future version of the standard.
- The calculated daylight factors using the EN15193 equations are in general lower than the average daylight factors in the daylit area. However this could be reasonable, because lighting would be normally be switched or dimmed according to the lowest daylight levels under each row of luminaires.
- The calculated daylight factors do not seem to vary enough with window width, and overestimated the effect of a courtyard and atrium.
- In reality, lighting use would be expected to vary smoothly with window area. However the EN15193 equations predict little or no change, then sudden drops in LENI as window area increases. Partly this is because of the way in which the LENI is not based directly on the daylight factor, but instead on a classification of daylight levels into 'low' 'medium' or 'high'; and partly because as window width increases, the daylit zone is larger and additional luminaires are assumed to be switched or dimmed.
- In the current EN15193, the savings from using automatic daylight linked controls do not depend on whether they are switching or dimming controls. This is proposed to be corrected in a future version of the standard. The savings tend to be overestimated in areas with switching controls and relatively low levels of daylight.

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Climate based daylight modelling gives a much more sophisticated, and potentially more accurate, method to predict daylight provision and lighting use. It includes concepts such as daylight autonomy and useful daylight index to categorise daylight provision. Daylight autonomy is the proportion of the year (usually set operating hours within the year) for which daylight illuminance exceeds a particular value. Daylight autonomy has the advantage that it is directly linked to the savings that can be achieved from automatic daylight linked controls, and it includes the effects of orientation.

Useful daylight illuminance is the proportion of the year for which daylight illuminance falls with a 'useful' range. This approach has been questioned, particularly the idea that high illuminances automatically are not useful, and there is still uncertainty about what the useful range should be. Nevertheless, useful daylight illuminance is a potentially valuable metric, because it encourages the daylight designer to think about shading as an integral part of the daylight design process. In offices and school classrooms, its use tends to lead to designs with appropriate shading, good uniformity, and where possible high level glazing and either rooflights or windows in more than one wall.

In practice the definitions of daylight autonomy and useful daylight illuminance can vary. The target illuminance above which daylight is deemed sufficient, and the maximum illuminance, above which it is seen as excessive, can vary between authors and standards. The definition of yearly operating hours can vary according to the type of building. The metrics may refer to the illuminance at a particular point within the space (often a mid point), or an average illuminance over the whole space, or the proportion of points with a given daylight autonomy. Thus climate based daylight recommendations which look similar may result in quite different levels of daylight provision.

The detailed calculation methods used to generate daylight autonomy and useful daylight illuminance can also affect the results obtained. Issues like the choice of grid size, the use of an offset excluding points close to the walls, the time step for calculation, the weather data file and assumptions about the way shading is operated can particularly affect useful daylight illuminance, as it is influenced by the best and worst lit areas in the room, and on illuminances on particularly bright and dull days. Future standards based on these quantities should give clear guidance on these calculation issues.

Recommendations based on the new metrics also need to take into account the type of space to which they apply. Spaces which require higher illuminances, for example retail, tend to have lower daylight autonomy. Also, useful daylight illuminance may be a less appropriate metric in domestic type spaces where high illuminances could be welcome.

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Acknowledgements

This work was funded jointly by the BRE Trust and by the research fund of the Chartered Institution of Building Services Engineers. We would like to thank Richard Daniels of the Education Funding Agency, John Mardaljevic of Loughborough University, Andrew Bissell of Cundall, Paul Sperring and Iain Hill of Mott Macdonald, and Chris Jackson of Lighting Analysts, for taking part in a workshop and giving us the benefit of their expertise.

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References

1. British Standards Institution ‘Lighting for buildings - Part 2. Code of Practice for daylighting’ BS8206 Part 2. London, BSI, 2008.
2. Chartered Institution of Building Services Engineers/Society of Light and Lighting. Lighting Guide 10. ‘Daylighting and window design’ London, CIBSE, 1999 (currently under revision).
3. Littlefair P J, ‘Site layout planning for daylight and sunlight; a guide to good practice’ BRE report, Bracknell, IHS/BRE Press, 2011.
4. Bell J and Burt W ‘Designing buildings for daylight’ BRE report. Bracknell, IHS BRE Press, 1995.
5. BREEAM Technical Manual, 2014. Available at www.breeam.org
6. Tregenza P R ‘The daylight factor and actual illuminance ratios’ Ltg Res and Technol 12 (2) 64-68, 1980.
7. Littlefair P J ‘Measuring daylight’ BRE information paper IP23/93, Bracknell, IHS BRE Press, 1993.
8. Littlefair P J 'Predicting annual lighting use in daylit buildings' Building and Environment 25 (1) 43-54, 1990.
9. Bissell A ‘New sky thinking’ Lighting Journal 79 (8) 11-14, 2014.
10. Littlefair P J ‘Designing with innovative daylighting’ BRE report. CRC, Garston, 1996.
11. Waldram P J. ‘Measuring and predicting daylight illumination’ The Builder 1 Oct 1937, p 598.
12. Phillips R O, ‘An historical outline of the concepts and terminology of daylight’ Proc CIE, Zurich v2, 1955.
13. Hunt D R G, ‘The use of artificial lighting in relation to daylight levels and occupancy’ Building and Environment 14 (1) 21-33, 1979.
14. Boyce P R, ‘Observations of the manual switching of lighting’ Ltg Res and Technol 12 (4) 195-205, 1980.
15. British Standards Institution. ‘Energy performance of buildings — Energy requirements for lighting’ BS EN15193. London, BSI, 2007.
16. British Standards Institution. ‘Energy performance of buildings —Module M9- Energy requirements for lighting. Part 1. Specifications’ prEN15193-1. Draft for public comment. London, BSI, 2014.
17. British Standards Institution. ‘Energy performance of buildings —Energy requirements for lighting. Part 2. Technical Report to EN15193-1’ prCEN/TR 15193-2. Working document. London, BSI, 2014.
18. Mardaljevic J, ‘The simulation of annual daylighting profiles for internal illuminance’ Ltg Res and Technol 32 (3) 111-118, 2000.
19. CIBSE, ‘Weather, solar and illuminance data’ CIBSE Guide J. London, CIBSE, 2002.

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20. Littlefair P J, 'The luminous efficacy of daylight: a review' Ltg Res & Technol 17 (4) 162-182, 1985.

21. Tregenza P and Waters, I M, 'Daylight coefficients' Ltg Res and Technol 15 (2) 65-71, 1983.

22. Littlefair P J, 'Daylight coefficients for practical computation of internal illuminances' Ltg Res and Technol 24 (3) 127-135, 1992.

23. Mardaljevic J, Andersen M, Roy N and Christoffersen, J 'Daylighting Metrics for Residential Buildings' Proceedings of 27th Session of the CIE, Sun City, South Africa, July 11-15, 2011.

24. Walkenhorst O, Luther J, Reinhart C and Timmer J, 'Dynamic annual daylight simulations based on one-hour and one-minute means of irradiance data' Solar Energy 72 (5) 385-395, 2002.

25. Reinhart CF, Mardaljevic J, Rogers Z, 'Dynamic daylight performance metrics for sustainable building design' Leukos 3 (1) 7-31, 2006.

26. Association Suisse des Electriciens. 'Eclairage interieur par la lumiere du jour' Swiss Norm SN 418911, Zurich, 1989.

27. Reinhart CF and Walkenhorst O. 'Dynamic RADIANCE-based daylight simulations for a fullscale test office with outer venetian blinds'. Energy & Buildings. 33(7):683–697, 2001.

28. Society of Light and Lighting. 'Code for Lighting'. London, CIBSE, 2012.

29. British Standards Institution. 'Light and lighting – Lighting of work places. Part 1: Indoor workplaces' BS EN12464-1. London, BSI, 2011.

30. Rogers Z. Daylighting metric development using daylight autonomy calculations in the Sensor Placement Optimization Tool: Development report and case studies. Boulder, Colorado, Architectural Energy Corporation, 2006. Available at http://www.daylightinginnovations.com/system/public_assets/original/SPOT_Daylight%20Autonomy%20Report.pdf [downloaded 24 September 2014).

31. Illuminating Engineering Society. 'Approved method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)'. LM 83-12, New York, IES, 2012.

32. Heschong L, 'Daylight Metrics: PIER Daylighting Plus Research Program' Gold River (CA), Heschong Mahone Group, 2012.

33. Education Funding Agency. 'Contractors Framework Invitation to tender volume 5: Facilities Output Specification: Part B Generic Design Brief' London, EFA, December 2013.

34. Education Funding Agency. 'EFA Daylight Design Guide' London, EFA, January 2014.

35. British Standards Institution, 'Daylighting of buildings' CEN TC169 WG11 draft for private circulation, January 2014.

36. Mardaljevic J, 'Daylight Performance Criteria' Proc Energy Forum: Advanced Building Skins, Bressanone, Italy, 5–6 November 2013.

37. Hunt DRG 'Availability of daylight' BRE Report. Bracknell, IHS BRE Press, 1979.

38. Nabil A and Mardaljevic J, 'Useful daylight illuminance: a new paradigm for assessing daylight in buildings', Ltg Res and Technol, 37 (1) 41-57, 2005.

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39. A Nabil and J Mardaljevic, 'Useful daylight illuminances: A replacement for daylight factors' Energy and Buildings 38 (7), 905-913, 2006.

40. Mardaljevic J, Andersen M, Roy N and Christoffersen J, 'Daylighting metrics: is there a relation between useful daylight illuminance and daylight glare probability?' Proc Building Simulation and Optimisation BSO12, Loughborough, UK, 10-11 September 2012. Available at http://infoscience.epfl.ch/record/179939/files/2012_Mardaljevical%20BSO2012%20UDI-DGPsComp_FINAL.pdf [downloaded 25 September 2014]

41. Littlefair PJ 'Daylighting design for display screen equipment' BRE Information Paper IP10/95. Bracknell, IHS BRE Press, 1995.

42. Buchner A, Mayr S and Brandt M. 'The advantage of positive text-background polarity is due to high display luminance' Ergonomics 52 (7) 882-6, 2009.

43. Roche L, Dewey E and Littlefair P J 'Occupant reactions to daylight in offices' Lighting Research and Technology, Vol. 32, No. 3, 119-126 (2000)

44. Roche L, Dewey E, Littlefair P J and Slater A I 'Occupant reactions to daylight in offices' Proc Lux Europa, Reykjavik, 2001.

45. Neeman E, Craddock J and Hopkinson R G, 'Sunlight requirements in buildings –I. Social survey' Building and Environment 11 217-238, 1976.

46. Littlefair PJ 'Predicting annual lighting use in daylit buildings' Building and Environment 25 (1) 43-54, 1990.

47. Lynes JA and Littlefair PJ 'Lighting energy savings from daylight: estimation at the sketch design stage' Lighting Research and Technology 22 (3) 129-137, 1990.

48. Littlefair PJ 'Daylight availability for lighting controls' Proceedings CIBS National Lighting Conference, Cambridge, 1984 pp 215-233. London, CIBSE, 1984.

49. Littlefair PJ 'A new method for predicting energy saving from on/off photoelectric controls' Building Research Establishment Information Paper IP 14/84 Bracknell, IHS BRE Press, 1984.

50. Littlefair PJ 'Photoelectric control: the effectiveness of techniques to reduce switching frequency' Lighting Research and Technology 33 (1) 43-55, 2001.

51. Hunt DRG 'Simple expressions for predicting energy savings from photoelectric control of lighting' Lighting Research & Technology 9 (2) 93-102, 1977.

52. Hunt DRG 'Improved daylight data for predicting energy savings from photoelectric controls' Lighting Research and Technology 11 (1) 9-23, 1979.

53. Littlefair P J 'Predicting lighting energy use under daylight linked lighting controls', Building Research & Information, 26 (4) 208-222, 1998.

54. Warren M, Selkowitz S et al 'Lighting system performance in an innovative daylighted structure: an instrumented study' Proc 2nd Int Daylighting Conference, Long Beach pp 215-221. McLean VA, Cable Associates, 1986.

55. Littlefair P J 'Selecting lighting controls' BRE Digest 498. Bracknell, IHS BRE Press, 2014.

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56. Hunt DRG 'Predicting lighting use - a method based upon observed patterns of behaviour' Lighting Research & Technology 12 (1) 7-14, 1980.

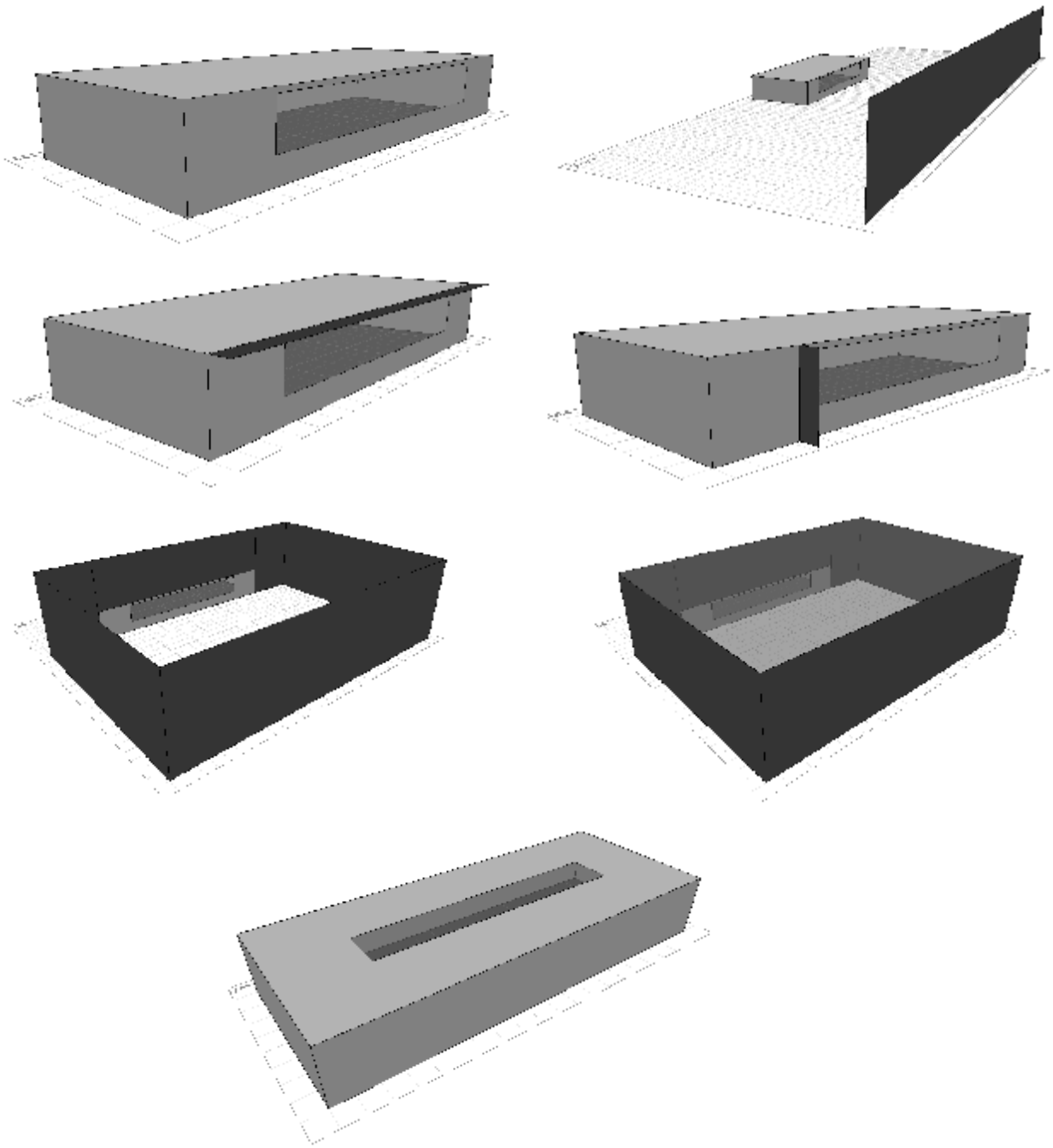
57. Lynes J A and Littlefair P J, ‘Adaptation: responding to change’ Lt and Ltg (7) 27-28, (April) 1999. Available at http://www.bdonline.co.uk/adaptation-responding-to-change/9127.article [downloaded 29 September 2014].

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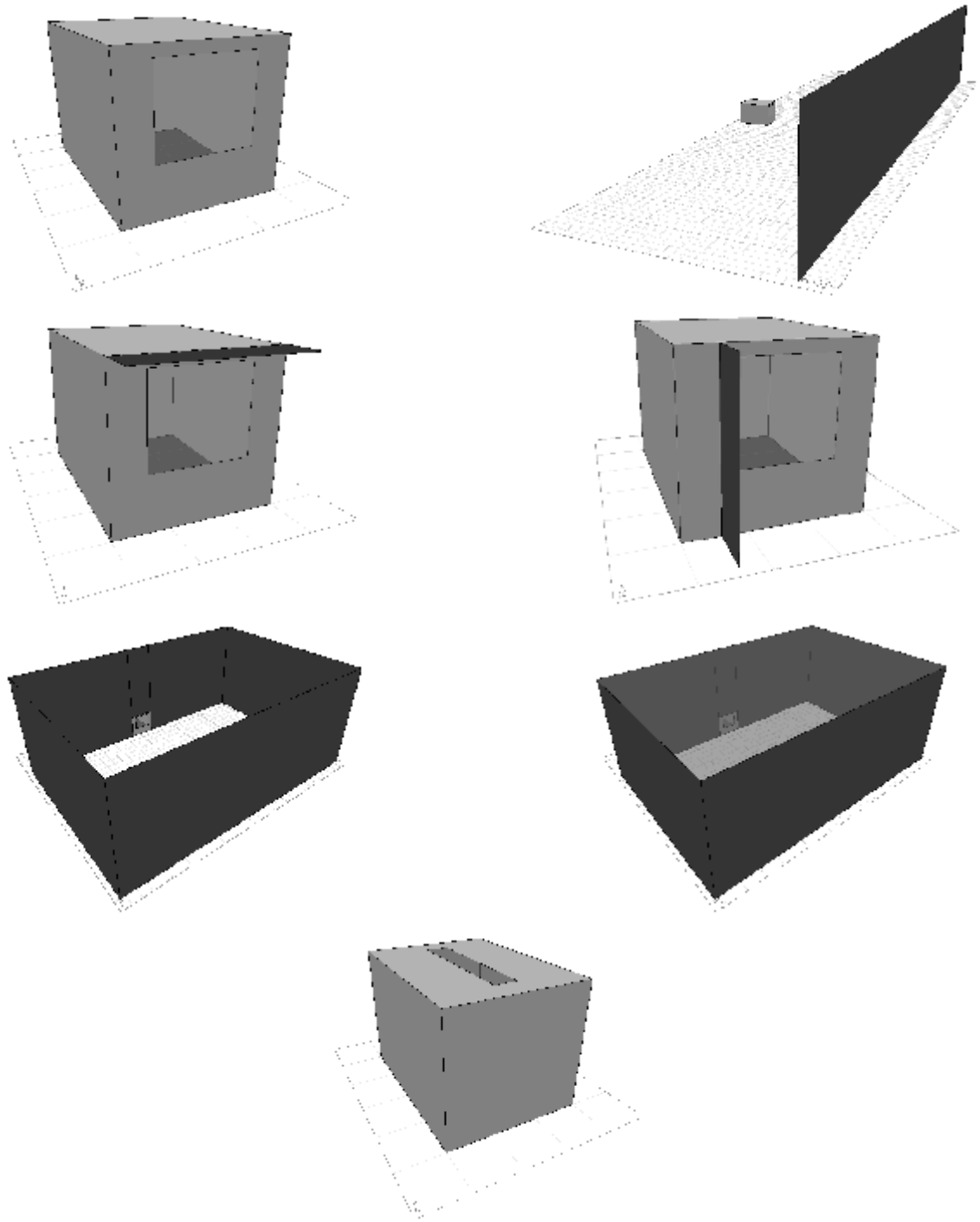
Appendix A Results of computer modelling

Figure A.1 Examples of large room used in the modelling. From top to bottom and left to right: side-lit, no external obstruction; side-lit, linear obstruction; side-lit, overhang; side-lit, vertical fin; side-lit, courtyard; side-lit, atrium; and top-lit, no external obstruction.



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Figure A.2 Examples of small room used in the modelling. From top to bottom and left to right: side-lit, no external obstruction; side-lit, linear obstruction; side-lit, overhang; side-lit, vertical fin; side-lit, courtyard; side-lit, atrium; and top-lit, no external obstruction.



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Table A.1 Daylight factors (DF) calculated for the large side-lit rooms (values expressed in %).

Scenario		Window width	DF by EN15193		DF by Dialux		DF by ADF Formula **	DF by Radiance	
			Excel *	Dialux *	*	**		*	**
No obstruction	1	8.4	2.97	2.99	4.64	1.92	1.49	4.83	2.36
	2	10	3.08	3.08	4.88	2.28	1.77	5.02	2.65
	3	11.6	3.15	3.18	5.08	2.64	2.05	5.16	2.95
	4	13.4	3.22	3.22	5.26	3.04	2.37	5.32	3.29
	5	15	3.27	3.27	5.40	3.39	2.65	5.42	3.57
	6	16.6	3.31	3.32	5.55	3.74	2.93	5.54	3.87
	7	18.4	3.48	3.51	5.89	4.10	3.24	5.83	4.17
	8	20	3.76	3.74	6.29	4.37	3.52	6.22	4.42
Linear obstruction	1	8.4	2.59	2.61	4.18	1.62	1.13	4.31	2.04
	2	10	2.67	2.65	4.39	1.93	1.34	4.48	2.29
	3	11.6	2.74	2.75	4.56	2.24	1.55	4.62	2.52
	4	13.4	2.80	2.80	4.72	2.58	1.79	4.75	2.80
	5	15	2.84	2.84	4.84	2.88	2.00	4.83	3.03
	6	16.6	2.88	2.89	4.97	3.17	2.21	4.92	3.27
	7	18.4	3.03	3.03	5.27	3.48	2.44	5.20	3.52
	8	20	3.27	3.27	5.62	3.71	2.65	5.51	3.72
Overhang	1	8.4	1.99	1.99	3.07	1.37	1.01	3.72	1.98
	2	10	2.06	2.04	3.23	1.62	1.20	3.85	2.20
	3	11.6	2.11	2.13	3.37	1.86	1.39	3.97	2.41
	4	13.4	2.16	2.18	3.49	2.13	1.60	4.08	2.67
	5	15	2.19	2.18	3.59	2.38	1.79	4.17	2.91
	6	16.6	2.22	2.23	3.70	2.62	1.98	4.24	3.27
	7	18.4	2.33	2.32	3.93	2.86	2.19	4.51	3.38
	8	20	2.52	2.51	4.24	3.07	2.37	4.79	3.57
Vertical fin	1	8.4	2.86	2.89	4.52	1.88	1.67	4.73	2.34
	2	10	2.98	2.99	4.77	2.24	1.99	4.93	2.61
	3	11.6	3.07	3.08	4.98	2.60	2.30	5.10	2.94
	4	13.4	3.14	3.13	5.17	3.00	2.66	5.24	3.26
	5	15	3.20	3.22	5.32	3.35	2.97	5.36	3.55
	6	16.6	3.25	3.27	5.47	3.69	3.29	5.47	3.83
	7	18.4	3.42	3.41	5.82	4.05	3.64	5.79	4.14
	8	20	3.70	3.70	6.21	4.32	3.95	6.19	4.43

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Scenario		Window width	DF by EN15193		DF by Dialux		DF by ADF Formula **	DF by Radiance	
			Excel *	Dialux *	*	**		*	**
Courtyard	1	8.4	2.13	2.13	4.11	1.66	1.29	4.30	2.03
	2	10	2.20	2.23	4.29	1.94	1.53	4.46	2.28
	3	11.6	2.26	2.28	4.42	2.22	1.77	4.56	2.50
	4	13.4	2.31	2.32	4.54	2.52	2.05	4.67	2.77
	5	15	2.34	2.32	4.63	2.79	2.29	4.74	2.99
	6	16.6	2.37	2.37	4.70	3.05	2.53	4.79	3.21
	7	18.4	2.49	2.51	4.94	3.30	2.80	5.03	3.45
	8	20	2.69	2.70	5.22	3.49	3.04	5.29	3.59
Atrium	1	8.4	0.72	0.71	1.49	0.66	0.44	2.10	1.26
	2	10	0.75	0.76	1.55	0.76	0.52	2.17	1.35
	3	11.6	0.77	0.76	1.60	0.86	0.60	2.19	1.44
	4	13.4	0.78	0.81	1.64	0.96	0.70	2.23	1.54
	5	15	0.80	0.81	1.68	1.05	0.78	2.27	1.63
	6	16.6	0.81	0.81	1.70	1.14	0.86	2.30	1.72
	7	18.4	0.85	0.85	1.78	1.22	0.95	2.38	1.79
	8	20	0.92	0.90	1.87	1.29	1.04	2.48	1.87

Notes

* Over daylit zone only (as defined by EN15193)

** Over entire space

No working plane offset in Dialux and Radiance.

Framing factor 0.85 and maintenance factor 0.8 considered in Radiance.

Framing factor 0.85, maintenance (pollution) factor 0.8 and correction factor for non-normal light rays 0.85 considered in Dialux.

Maintenance factor 0.8 and framing factor 0.85 in ADF formula; diffuse visible light transmittance obtained by multiplying direct visible light transmittance by 0.85 (to match the correction factor for non-normal light rays).

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Table A.2 Daylight factors (DF) calculated for the small side-lit rooms (values expressed in %).

Scenario		Window width	DF by EN15193		DF by Dialux	DF by ADF Formula	DF by Radiance
			Excel	Dialux			
No obstruction	1	1.1	1.92	1.75	2.34	1.34	2.17
	2	1.4	2.29	2.13	2.92	1.71	2.76
	3	1.6	2.54	2.37	3.31	1.95	3.14
	4	1.8	2.80	2.61	3.67	2.19	3.52
	5	2.1	3.18	2.99	4.20	2.55	4.08
	6	2.4	3.56	3.37	4.71	2.91	4.61
	7	2.6	3.81	3.65	5.03	3.14	4.95
	8	2.9	4.19	4.03	5.46	3.50	5.42
Linear obstruction	1	1.1	1.31	1.18	1.70	0.81	2.09
	2	1.4	1.57	1.47	2.10	1.03	2.47
	3	1.6	1.75	1.61	2.39	1.18	2.72
	4	1.8	1.92	1.80	2.65	1.32	2.96
	5	2.1	2.18	2.09	3.02	1.54	3.33
	6	2.4	2.44	2.32	3.40	1.76	3.69
	7	2.6	2.62	2.51	3.62	1.90	3.89
	8	2.9	2.88	2.75	3.93	2.12	4.20
Overhang	1	1.1	1.19	1.09	1.71	0.88	1.52
	2	1.4	1.43	1.14	2.09	1.11	1.94
	3	1.6	1.59	1.47	2.36	1.27	2.21
	4	1.8	1.74	1.61	2.61	1.43	2.49
	5	2.1	1.98	1.85	2.97	1.66	2.91
	6	2.4	2.22	2.09	3.33	1.90	3.31
	7	2.6	2.37	2.28	3.57	2.05	3.58
	8	2.9	2.61	2.51	3.93	2.28	3.98
Vertical fin	1	1.1	1.56	1.42	2.04	1.25	1.81
	2	1.4	1.92	1.75	2.61	1.66	2.38
	3	1.6	2.16	1.99	2.98	1.94	2.75
	4	1.8	2.41	2.28	3.33	2.23	3.13
	5	2.1	2.78	2.61	3.85	2.66	3.67
	6	2.4	3.16	2.99	4.35	3.09	4.20
	7	2.6	3.41	3.27	4.65	3.39	4.55
	8	2.9	3.78	3.60	5.10	3.82	5.00

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Scenario		Window width	DF by EN15193		DF by Dialux	DF by ADF Formula	DF by Radiance
			Excel	Dialux			
Courtyard	1	1.1	1.10	1.00	1.84	0.98	1.63
	2	1.4	1.32	1.23	2.23	1.24	2.06
	3	1.6	1.46	1.37	2.50	1.41	2.34
	4	1.8	1.61	1.52	2.76	1.59	2.61
	5	2.1	1.83	1.71	3.12	1.85	3.02
	6	2.4	2.04	1.94	3.48	2.11	3.41
	7	2.6	2.19	2.09	3.69	2.29	3.64
	8	2.9	2.41	2.32	3.98	2.54	3.98
Atrium	1	1.1	0.38	0.33	0.85	0.33	0.73
	2	1.4	0.45	0.43	0.98	0.42	0.92
	3	1.6	0.50	0.47	1.08	0.48	1.02
	4	1.8	0.55	0.52	1.14	0.54	1.15
	5	2.1	0.62	0.57	1.26	0.63	1.34
	6	2.4	0.70	0.66	1.38	0.72	1.49
	7	2.6	0.75	0.71	1.45	0.78	1.59
	8	2.9	0.82	0.81	1.55	0.87	1.72

Notes

No working plane offset in Dialux and Radiance.

Framing factor 0.85 and maintenance factor 0.8 considered in Radiance.

Framing factor 0.85, maintenance (pollution) factor 0.8 and correction factor for non-normal light rays 0.85 considered in Dialux.

Maintenance factor 0.8 and framing factor 0.85 in ADF formula; diffuse visible light transmittance obtained by multiplying direct visible light transmittance by 0.85 (to match the correction factor for non-normal light rays).

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Table A.3 Daylight factors (DF) calculated for the large top-lit rooms (values expressed in %).

Scenario		Rooflight length	DF by EN15193		DF by Dialux		DF by ADF Formula **	DF by Radiance	
			Excel *	Dialux *	*	**		*	**
2m wide rooflight	1	1.6	2.60	2.40	2.29	0.70	0.70	2.54	0.73
	2	3.2	4.16	3.80	3.82	1.41	1.38	4.19	1.47
	3	4.8	5.18	4.80	4.87	2.12	2.07	5.31	2.20
	4	6.4	5.88	5.40	5.65	2.83	2.75	6.11	2.94
	5	8	6.39	6.00	6.22	3.52	3.42	6.70	3.67
	6	9.6	6.78	6.30	6.67	4.21	4.09	7.16	4.40
	7	11.2	7.09	6.60	7.03	4.89	4.75	7.54	5.13
	8	12.8	7.33	6.90	7.33	5.57	5.41	7.85	5.84

Notes

* Over daylit zone only (as defined by EN15193)

** Over entire space

No working plane offset in Dialux and Radiance.

Framing factor 0.85 and maintenance factor 0.8 considered in Radiance.

Framing factor 0.85, maintenance (pollution) factor 0.8 and correction factor for non-normal light rays 0.85 considered in Dialux.

Maintenance factor 0.8 and framing factor 0.85 in ADF formula; diffuse visible light transmittance obtained by multiplying direct visible light transmittance by 0.85 (to match the correction factor for non-normal light rays).

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Table A.4 Daylight factors (DF) calculated for the small top-lit rooms (values expressed in %).

Scenario		Rooflight length	DF by EN15193		DF by Dialux	DF by ADF Formula	DF by Radiance
			Excel	Dialux			
0.5m wide rooflight	1	0.5	0.41	0.40	0.49	0.43	0.51
	2	1	0.80	0.70	0.97	0.85	1.06
	3	1.4	1.12	1.00	1.34	1.19	1.49
	4	1.9	1.53	1.40	1.81	1.61	2.02
	5	2.4	1.93	1.80	2.24	2.03	2.53
	6	2.9	2.34	2.20	2.66	2.45	3.01
	7	3.4	2.76	2.60	3.04	2.86	3.46
	8	3.8	3.09	2.90	3.32	3.19	3.80

Notes

No working plane offset in Dialux and Radiance.

Framing factor 0.85 and maintenance factor 0.8 considered in Radiance.

Framing factor 0.85, maintenance (pollution) factor 0.8 and correction factor for non-normal light rays 0.85 considered in Dialux.

Maintenance factor 0.8 and framing factor 0.85 in ADF formula; diffuse visible light transmittance obtained by multiplying direct visible light transmittance by 0.85 (to match the correction factor for non-normal light rays).

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Table A.5 Large room examples – Relative difference between daylight factors (DF) calculated by Dialux & Radiance computer modelling and those calculated by EN15193 method.

Scenario		DF by Dialux compared to DF by EN15193 in		DF by Radiance compared to DF by EN15193 in	
		Excel	Dialux	Excel	Dialux
Side-lit, no obstruction	Minimum	56%	55%	63%	62%
	Maximum	69%	68%	68%	67%
	Average	64%	63%	65%	65%
Side-lit, linear obstruction	Minimum	61%	60%	66%	65%
	Maximum	74%	74%	72%	71%
	Average	69%	69%	69%	69%
Side-lit, overhang	Minimum	54%	54%	87%	86%
	Maximum	69%	69%	94%	94%
	Average	62%	62%	89%	89%
Side-lit, vertical fin	Minimum	58%	56%	65%	64%
	Maximum	70%	71%	69%	70%
	Average	65%	64%	67%	67%
Side-lit, courtyard	Minimum	93%	93%	97%	96%
	Maximum	98%	99%	103%	104%
	Average	96%	95%	101%	101%
Side-lit, atrium	Minimum	103%	104%	170%	175%
	Maximum	110%	111%	192%	195%
	Average	108%	108%	184%	184%
Top-lit, no obstruction	Minimum	-12%	-5%	-2%	6%
	Maximum	0%	7%	7%	14%
	Average	-4%	3%	4%	12%

Note

The daylight factor values calculated apply to the daylit area only as per the EN15193 method.

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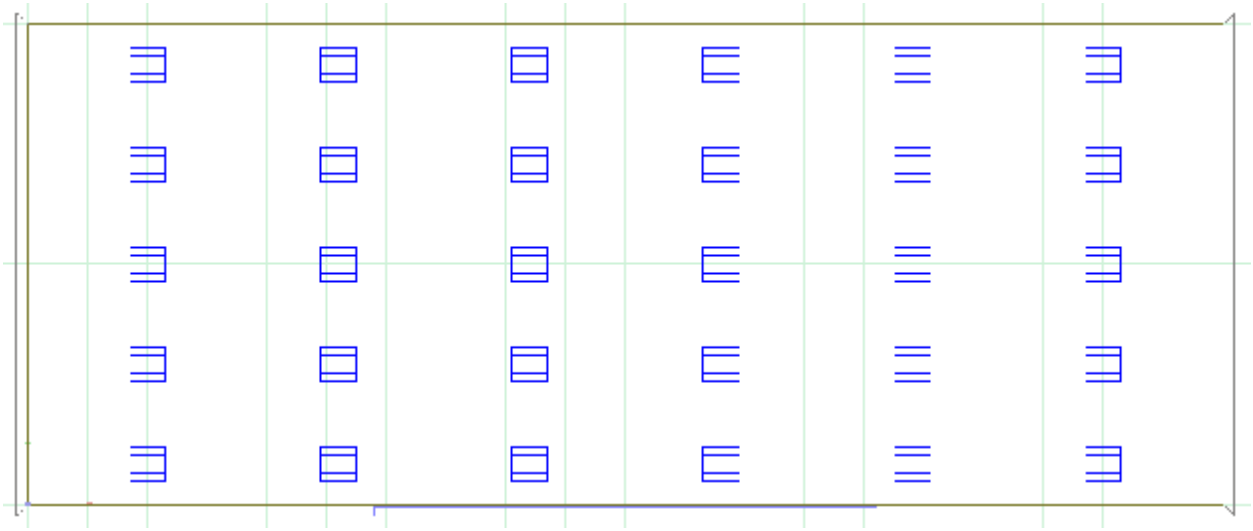
Table A.6 Small room examples – Relative difference between daylight factors (DF) calculated by Dialux & Radiance computer modelling and ADF formula and those calculated by EN15193 method.

Scenario		DF by Dialux compared to DF by EN15193 in		DF by Radiance compared to DF by EN15193 in		DF by ADF formula compared to DF by EN15193 in	
		Excel	Dialux	Excel	Dialux	Excel	Dialux
Side-lit, no obstruction	Minimum	22%	33%	13%	24%	-30%	-23%
	Maximum	32%	41%	30%	37%	-16%	-13%
	Average	30%	38%	25%	33%	-22%	-17%
Side-lit, linear obstruction	Minimum	30%	43%	46%	53%	-38%	-31%
	Maximum	39%	48%	60%	76%	-26%	-23%
	Average	36%	45%	53%	63%	-31%	-27%
Side-lit, overhang	Minimum	44%	56%	28%	39%	-26%	-20%
	Maximum	51%	84%	52%	71%	-13%	-2%
	Average	49%	62%	43%	56%	-18%	-11%
Side-lit, vertical fin	Minimum	31%	42%	16%	27%	-20%	-12%
	Maximum	38%	50%	33%	41%	1%	6%
	Average	36%	46%	28%	37%	-7%	-1%
Side-lit, courtyard	Minimum	65%	71%	48%	64%	-11%	-2%
	Maximum	71%	85%	67%	77%	6%	10%
	Average	69%	80%	61%	71%	-1%	5%
Side-lit, atrium	Minimum	89%	92%	92%	113%	-12%	-1%
	Maximum	124%	156%	116%	136%	6%	11%
	Average	106%	120%	108%	121%	-1%	5%
Top-lit, no obstruction	Minimum	7%	14%	23%	28%	3%	7%
	Maximum	21%	39%	33%	51%	7%	22%
	Average	16%	25%	29%	39%	5%	13%

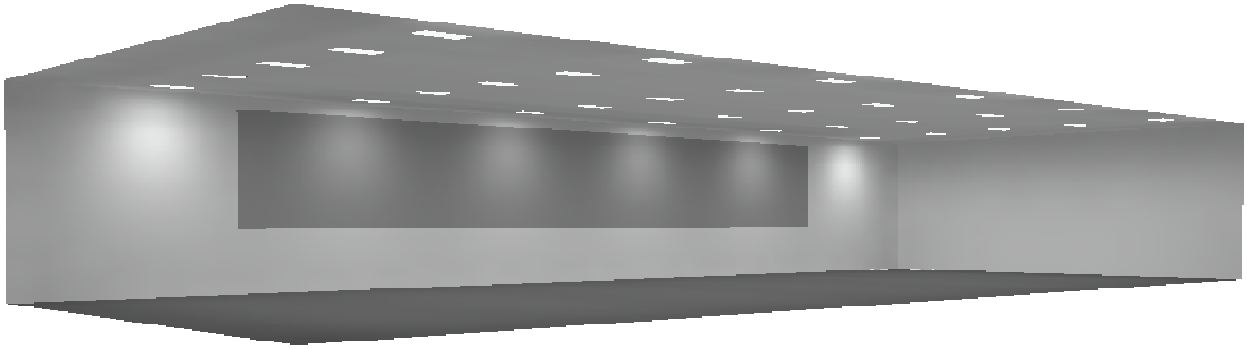
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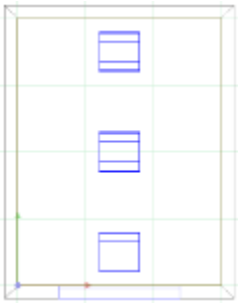
Appendix B Results of LENI calculations

Figure B.1 Illustration of the electric lighting systems considered in the example rooms.



Large room







Small room

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Table B.1 LENI values calculated for the large side-lit rooms (values expressed in kWh/m^2,year).

Scenario		Window width	LENI by EN15193:2007		LENI by prEN15193-1 rev		
			in Excel	in Dialux	South	East/West	North
No obstruction	1	8.4	17.38	16.48	16.88	17.14	17.43
	2	10	16.48	16.48	16.87	17.13	17.42
	3	11.6	16.48	16.48	16.86	17.12	17.41
	4	13.4	16.48	16.48	16.86	17.11	17.40
	5	15	14.78	14.78	15.34	15.73	16.15
	6	16.6	14.78	14.78	15.34	15.72	16.15
	7	18.4	14.78	14.78	15.31	15.69	16.12
	8	20	14.78	14.78	15.28	15.65	16.07
Linear obstruction	1	8.4	17.38	17.38	17.14	17.38	17.64
	2	10	17.38	17.38	17.13	17.36	17.61
	3	11.6	17.38	17.38	17.11	17.34	17.59
	4	13.4	17.38	17.38	17.10	17.32	17.57
	5	15	16.13	14.78	15.44	15.84	16.28
	6	16.6	16.13	14.78	15.42	15.82	16.26
	7	18.4	14.78	14.78	15.37	15.76	16.19
	8	20	14.78	14.78	15.34	15.73	16.15
Overhang	1	8.4	18.27	17.38	17.30	17.55	17.84
	2	10	17.38	17.38	17.29	17.53	17.82
	3	11.6	17.38	17.38	17.27	17.52	17.80
	4	13.4	17.38	17.38	17.26	17.50	17.78
	5	15	16.13	16.13	15.94	16.31	16.73
	6	16.6	16.13	16.13	15.93	16.29	16.71
	7	18.4	16.13	16.13	15.89	16.24	16.65
	8	20	16.13	16.13	15.81	16.16	16.56
Vertical fin	1	8.4	17.38	16.48	16.91	17.17	17.48
	2	10	17.38	16.48	16.88	17.14	17.44
	3	11.6	16.48	16.48	16.87	17.13	17.42
	4	13.4	16.48	16.48	16.86	17.12	17.41
	5	15	14.78	14.78	15.35	15.74	16.17
	6	16.6	14.78	14.78	15.35	15.73	16.16
	7	18.4	14.78	14.78	15.32	15.70	16.13
	8	20	14.78	14.78	15.29	15.66	16.08

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Scenario		Window width	LENI by EN15193:2007		LENI by prEN15193-1 rev		
			in Excel	in Dialux	South	East/West	North
Courtyard	1	8.4	17.38	17.38	17.26	17.51	17.79
	2	10	17.38	17.38	17.25	17.49	17.77
	3	11.6	17.38	17.38	17.23	17.47	17.75
	4	13.4	17.38	17.38	17.22	17.46	17.73
	5	15	16.13	16.13	15.88	16.24	16.65
	6	16.6	16.13	16.13	15.87	16.23	16.63
	7	18.4	16.13	16.13	15.82	16.17	16.57
	8	20	16.13	16.13	15.75	16.09	16.47
Atrium	1	8.4	20.34	20.34	20.34	20.34	20.34
	2	10	20.34	20.34	20.34	20.34	20.34
	3	11.6	20.34	20.34	20.34	20.34	20.34
	4	13.4	20.34	20.34	20.34	20.34	20.34
	5	15	20.58	20.58	20.58	20.58	20.58
	6	16.6	20.58	20.58	20.58	20.58	20.58
	7	18.4	20.58	20.58	20.58	20.58	20.58
	8	20	20.58	20.58	20.58	20.58	20.58

Notes

See Section 4 for details on room geometry and glazing properties.

Location of example rooms: London (latitude 51.5°N and longitude 0.1°W).

Electric lighting: 30 luminaires rated 44W each, with an assumed additional parasitic power of 0.5W per luminaire for emergency lighting and of 3W in daylit zones and 2W in non-daylit zones for lighting controls standby.

Usage type: offices, with a maintained average illuminance of 500 lux on the working plane.

Annual occupancy hours: typical for offices, with 2250 hours of daylight time usage and 250 hours of non-daylight time usage per year.

Lighting controls: automatic and daylight dependent, with manual switching on and automatic daylight-based dimming (occupancy control factor 0.90), absence detection using one sensor per 10 m^2 (absence factor 0.20) and maintenance of constant illuminance (constant illuminance factor of 0.90).

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Table B.2 LENI values calculated for the small side-lit rooms (values expressed in kWh/m^2,year).

Scenario		Window width	LENI by EN15193:2007		LENI by prEN15193-1 rev		
			in Excel	in Dialux	South	East/West	North
No obstruction	1	1.1	22.26	22.26	19.05	19.90	20.86
	2	1.4	19.28	19.28	18.76	19.58	20.48
	3	1.6	19.28	19.28	18.55	19.32	20.20
	4	1.8	19.28	19.28	18.33	19.07	19.91
	5	2.1	16.28	16.28	17.55	18.40	19.36
	6	2.4	16.28	16.28	17.44	18.28	19.22
	7	2.6	16.28	16.28	17.37	18.19	19.12
	8	2.9	16.28	16.28	17.25	18.07	18.98
Linear obstruction	1	1.1	22.26	22.26	20.86	21.43	22.21
	2	1.4	22.26	22.26	20.36	20.86	21.43
	3	1.6	22.26	22.26	20.27	20.75	21.30
	4	1.8	22.26	22.26	19.05	19.90	20.86
	5	2.1	19.28	19.28	18.86	19.67	20.60
	6	2.4	19.28	19.28	18.64	19.42	20.32
	7	2.6	19.28	19.28	18.48	19.25	20.12
	8	2.9	19.28	19.28	17.71	18.59	19.57
Overhang	1	1.1	22.26	22.26	21.19	21.81	22.51
	2	1.4	22.26	22.26	20.57	21.11	21.71
	3	1.6	22.26	22.26	20.35	20.84	21.41
	4	1.8	22.26	22.26	20.28	20.76	21.32
	5	2.1	22.26	22.26	19.02	19.86	20.82
	6	2.4	19.28	19.28	18.82	19.64	20.55
	7	2.6	19.28	19.28	18.70	19.49	20.39
	8	2.9	19.28	19.28	18.49	19.26	20.13
Vertical fin	1	1.1	22.26	22.26	20.37	20.87	21.43
	2	1.4	22.26	22.26	19.05	19.90	20.86
	3	1.6	19.28	19.28	18.88	19.70	20.63
	4	1.8	19.28	19.28	18.67	19.46	20.35
	5	2.1	19.28	19.28	18.35	19.10	19.94
	6	2.4	16.28	16.28	17.55	18.41	19.37
	7	2.6	16.28	16.28	17.48	18.33	19.28
	8	2.9	16.28	16.28	17.37	18.20	19.13

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Scenario		Window width	LENI by EN15193:2007		LENI by prEN15193-1 rev		
			in Excel	in Dialux	South	East/West	North
Courtyard	1	1.1	22.26	22.26	21.43	22.07	22.82
	2	1.4	22.26	22.26	20.86	21.43	22.07
	3	1.6	22.26	22.26	20.50	21.02	21.61
	4	1.8	22.26	22.26	20.34	20.83	21.40
	5	2.1	22.26	22.26	20.23	20.71	21.26
	6	2.4	19.28	19.28	18.98	19.82	20.76
	7	2.6	19.28	19.28	18.85	19.67	20.60
	8	2.9	19.28	19.28	18.67	19.46	20.35
Atrium	1	1.1	29.16	29.16	29.16	29.16	29.16
	2	1.4	29.16	29.16	29.16	29.16	29.16
	3	1.6	29.16	29.16	29.16	29.16	29.16
	4	1.8	29.16	29.16	29.16	29.16	29.16
	5	2.1	29.16	29.16	29.16	29.16	29.16
	6	2.4	29.16	29.16	29.16	29.16	29.16
	7	2.6	29.16	29.16	29.16	29.16	29.16
	8	2.9	29.16	29.16	29.16	29.16	29.16

Notes

See Section 4 for details on room geometry and glazing properties.

Location of example rooms: London (latitude 51.5°N and longitude 0.1°W).

Electric lighting: 3 luminaires rated 44W each, with an assumed additional parasitic power of 1W per luminaire for emergency lighting and of 3W for lighting controls standby.

Usage type: offices, with a maintained average illuminance of 500 lux on the working plane.

Annual occupancy hours: typical for offices, with 2250 hours of daylight time usage and 250 hours of non-daylight time usage per year.

Lighting controls: automatic and daylight dependent, with manual switching on and automatic daylight-based dimming (occupancy control factor 0.90), absence detection using one sensor per 10 m^2 (absence factor 0.20) and maintenance of constant illuminance (constant illuminance factor of 0.90).

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Table B.3 LENI values calculated for the large top-lit rooms (values expressed in kWh/m^2,year).

Scenario		Rooflight length	LENI by EN15193:2007		LENI by prEN15193-1 rev
			in Excel	in Dialux	
2m wide rooflight	1	1.6	18.40	18.40	18.62
	2	3.2	18.12	18.40	18.36
	3	4.8	18.12	18.12	18.21
	4	6.4	16.36	16.36	16.44
	5	8	16.36	16.36	16.35
	6	9.6	16.36	16.36	16.28
	7	11.2	15.69	16.36	16.12
	8	12.8	13.60	15.35	14.18

Notes

See Section 4 for details on room geometry and glazing properties.

Location of example rooms: London (latitude 51.5°N and longitude 0.1°W).

Electric lighting: 30 luminaires rated 44W each, with an assumed additional parasitic power of 0.5W per luminaire for emergency lighting and of 3W in daylit zones and 2W in non-daylit zones for lighting controls standby.

Usage type: offices, with a maintained average illuminance of 500 lux on the working plane.

Annual occupancy hours: typical for offices, with 2250 hours of daylight time usage and 250 hours of non-daylight time usage per year.

Lighting controls: automatic and daylight dependent, with manual switching on and automatic daylight-based dimming (occupancy control factor 0.90), absence detection using one sensor per 10 m^2 (absence factor 0.20) and maintenance of constant illuminance (constant illuminance factor of 0.90).

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Table B.4 LENI values calculated for the small top-lit rooms (values expressed in kWh/m^2,year).

Scenario		Rooflight length	LENI by EN15193:2007		LENI by prEN15193-1 rev
			in Excel	in Dialux	
0.5m wide rooflight	1	0.5	29.16	29.16	29.16
	2	1	29.16	29.16	29.16
	3	1.4	29.16	29.16	29.16
	4	1.9	29.16	29.16	29.16
	5	2.4	29.16	29.16	29.16
	6	2.9	17.73	17.73	19.42
	7	3.4	17.73	17.73	19.08
	8	3.8	17.73	17.73	18.81

Notes

See Section 4 for details on room geometry and glazing properties.

Location of example rooms: London (latitude 51.5°N and longitude 0.1°W).

Electric lighting: 3 luminaires rated 44W each, with an assumed additional parasitic power of 1W per luminaire for emergency lighting and of 3W for lighting controls standby.

Usage type: offices, with a maintained average illuminance of 500 lux on the working plane.

Annual occupancy hours: typical for offices, with 2250 hours of daylight time usage and 250 hours of non-daylight time usage per year.

Lighting controls: automatic and daylight dependent, with manual switching on and automatic daylight-based dimming (occupancy control factor 0.90), absence detection using one sensor per 10 m^2 (absence factor 0.20) and maintenance of constant illuminance (constant illuminance factor of 0.90).

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Appendix C Results of detailed daylight metric calculations

This appendix gives the results of all detailed daylight metric calculations undertaken for the large and small rooms. For each room type, full analysis was performed for no obstructions, linear obstruction, overhang and courtyard scenarios for the side-lit room, and for the unobstructed top-lit room. Three room types were used: small glazed area, intermediate glazed area (with single and multiple openings for the large room) and large glazed area.

Table C.1 Average daylight factor (ADF) calculated by various methods for each room type and obstruction scenario.

Scenario	ADF by	Side-lit room, no obstructions	Side-lit room, linear obstruction	Side-lit room, overhang	Side-lit room, courtyard	Top-lit room
Large room, small glazed area	Daysim	1.9	1.6	1.4	1.5	0.8
	Radiance	2.4	2.0	2.0	2.0	0.7
	ADF Formula	1.5	1.1	1.0	1.3	0.7
	Dialux	1.9	1.6	1.4	1.7	0.7
Large room, intermediate glazed area, single opening	Daysim	3.3	2.7	2.5	2.6	4.0
	Radiance	3.6	3.0	2.9	3.0	3.7
	ADF Formula	2.7	2.0	1.8	2.3	3.4
	Dialux	3.4	2.9	2.4	2.8	3.5
Large room, intermediate glazed area, multiple openings	Daysim	3.1	2.6	2.4	2.5	3.8
	Radiance	-	-	-	-	-
	ADF Formula	2.7	2.0	1.8	2.3	3.4
	Dialux	-	-	-	-	-
Large room, large glazed area	Daysim	4.1	3.4	3.1	3.3	6.3
	Radiance	4.4	3.7	3.6	3.6	5.8
	ADF Formula	3.5	2.7	2.4	3.0	5.4
	Dialux	4.4	3.7	3.1	3.5	5.6
Small room, small glazed area	Daysim	2.4	1.7	1.7	1.8	0.6
	Radiance	2.2	2.1	1.5	1.6	0.5
	ADF Formula	1.3	0.8	0.9	1.0	0.4
	Dialux	2.3	1.7	1.7	1.8	0.5
Small room, intermediate glazed area	Daysim	4.3	3.1	3.1	3.2	2.9
	Radiance	4.1	3.3	2.9	3.0	2.5
	ADF Formula	2.6	1.5	1.7	1.9	2.0
	Dialux	4.2	3.0	3.0	3.1	2.2
Small room, large glazed area	Daysim	5.5	3.9	4.1	3.9	4.2
	Radiance	5.4	4.2	4.0	4.0	3.8
	ADF Formula	3.5	2.1	2.3	2.5	3.2
	Dialux	5.5	3.9	3.9	4.0	3.3

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Table C.2 Large room, 500 lux target maintained illuminance: Results for whole room for average daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																								
	School	1.9	12.2	13%	48.7	50.6	0.7	3.3	25.5	26%	26.6	71.7	1.6	3.2	25.5	25%	26.3	72.8	0.9	4.1	35.5	37%	22.4	75.0	2.6
	Office 1	1.9	12.0	12%	49.3	50.0	0.7	3.3	25.0	25%	27.2	71.2	1.6	3.2	25.0	23%	26.8	72.2	1.0	4.1	34.8	36%	22.7	74.7	2.6
	Office 2	1.9	10.0	9%	56.8	42.7	0.6	3.3	20.9	18%	37.3	61.4	1.4	3.2	20.8	14%	36.9	62.3	0.8	4.1	29.0	26%	33.0	64.9	2.1
	East facing window																								
	School	1.9	19.6	18%	41.4	54.0	4.6	3.3	38.7	36%	23.7	67.3	9.1	3.1	39.4	38%	23.1	68.8	8.1	4.1	49.0	50%	20.0	67.8	12.3
	Office 1	1.9	18.5	17%	43.0	52.8	4.1	3.3	36.5	34%	24.6	67.3	8.1	3.1	37.2	35%	24.1	68.7	7.2	4.1	46.7	47%	20.6	68.4	11.0
	Office 2	1.9	15.4	12%	51.5	45.2	3.3	3.3	30.6	25%	34.4	59.1	6.4	3.1	31.1	23%	33.9	60.4	5.8	4.1	39.2	36%	30.6	60.6	8.8
	South facing window																								
	School	1.9	25.3	23%	37.5	55.1	7.4	3.3	48.4	47%	22.8	62.9	14.3	3.1	50.0	52%	22.3	64.5	13.2	4.1	58.1	66%	19.5	61.2	19.2
	Office 1	1.9	24.3	22%	38.4	54.6	7.0	3.3	46.7	45%	23.3	63.1	13.6	3.1	48.1	50%	22.8	64.7	12.5	4.1	56.6	62%	19.8	62.0	18.2
	Office 2	1.9	19.3	14%	48.6	46.1	5.3	3.3	37.3	29%	34.5	55.1	10.5	3.1	38.2	29%	34.1	56.4	9.5	4.1	45.4	40%	30.9	55.1	14.0
	West facing window																								
	School	1.9	15.4	14%	45.7	51.8	2.5	3.3	31.5	30%	26.2	68.8	5.0	3.1	31.6	31%	25.8	69.9	4.3	4.1	41.6	42%	22.1	70.9	7.0
	Office 1	1.9	16.5	15%	45.3	51.5	3.1	3.3	33.0	30%	26.2	67.6	6.1	3.1	33.3	32%	25.8	68.7	5.5	4.1	42.8	43%	21.9	69.6	8.4
	Office 2	1.9	14.3	10%	53.6	43.5	2.9	3.3	28.3	20%	36.7	57.5	5.8	3.1	28.6	18%	36.4	58.4	5.2	4.1	36.3	30%	32.6	59.6	7.9
Side-lit, linear obstruction	North facing window																								
	School	1.6	10.1	10%	61.7	37.8	0.7	2.7	20.0	21%	37.1	61.7	1.2	2.6	20.3	19%	36.4	62.9	0.7	3.4	27.0	29%	31.1	67.0	1.9
	Office 1	1.6	9.9	10%	62.3	37.1	0.7	2.7	19.6	20%	37.8	61.0	1.2	2.6	19.9	18%	37.1	62.2	0.7	3.4	26.4	28%	31.6	66.4	1.9
	Office 2	1.6	8.2	7%	68.5	31.1	0.6	2.7	16.2	15%	37.3	61.4	1.0	2.6	16.5	11%	36.9	62.3	0.6	3.4	21.9	20%	33.0	64.9	1.6
	East facing window																								
	School	1.6	14.4	14%	57.2	39.0	3.8	2.7	27.0	28%	35.4	57.2	7.3	2.6	27.8	29%	34.9	58.5	6.5	3.4	33.8	37%	29.3	61.6	9.1
	Office 1	1.6	13.7	13%	58.1	38.5	3.4	2.7	25.8	26%	36.2	57.3	6.5	2.6	26.5	27%	35.7	58.5	5.8	3.4	32.8	35%	30.4	60.9	8.7
	Office 2	1.6	11.3	10%	64.7	32.6	2.6	2.7	21.4	20%	45.4	49.6	5.1	2.6	21.8	17%	44.9	50.6	4.5	3.4	27.3	27%	40.0	53.3	6.7
	South facing window																								
	School	1.6	16.7	17%	54.3	39.8	5.8	2.7	30.6	34%	34.2	54.8	11.0	2.6	31.7	37%	33.7	56.1	10.3	3.4	37.7	45%	29.0	56.6	14.3
	Office 1	1.6	16.3	17%	55.2	39.2	5.6	2.7	29.7	32%	34.9	54.6	10.5	2.6	30.8	36%	34.3	55.9	9.8	3.4	36.7	44%	29.5	56.8	13.7
	Office 2	1.6	13.1	11%	63.1	32.6	4.3	2.7	23.9	22%	45.4	46.5	8.0	2.6	24.7	22%	44.9	47.6	7.5	3.4	29.7	30%	40.2	49.2	10.5
	West facing window																								
	School	1.5	11.9	12%	60.2	37.7	2.1	2.7	22.9	24%	37.3	58.5	4.2	2.6	23.3	25%	36.9	59.5	3.6	3.4	29.5	33%	31.6	62.8	5.7
	Office 1	1.5	12.4	12%	59.8	37.5	2.7	2.7	23.6	24%	37.4	57.4	5.2	2.6	24.1	25%	36.9	58.5	4.6	3.4	30.2	34%	31.6	61.4	6.9
	Office 2	1.5	10.6	10%	66.1	31.5	2.4	2.7	20.1	16%	46.8	48.5	4.7	2.6	20.5	14%	46.4	49.3	4.3	3.4	25.7	23%	41.5	52.2	6.2

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Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																								
	School	1.4	10.2	10%	51.6	48.4	0.1	2.5	21.8	20%	28.5	71.3	0.2	2.4	21.3	17%	27.9	72.0	0.1	3.1	31.5	30%	23.7	76.0	0.4
	Office 1	1.4	10.0	9%	52.2	47.8	0.0	2.5	21.3	20%	29.2	70.6	0.2	2.4	20.9	16%	28.6	71.3	0.1	3.1	30.8	30%	24.1	75.6	0.4
	Office 2	1.4	8.3	6%	59.4	40.5	0.0	2.5	17.6	12%	39.2	60.7	0.1	2.4	17.2	9%	38.8	61.2	0.1	3.1	25.5	18%	34.3	65.4	0.3
	East facing window																								
	School	1.4	16.9	15%	44.3	52.6	3.1	2.5	34.5	31%	25.1	68.8	6.1	2.4	34.9	31%	24.4	70.2	5.4	3.1	45.2	45%	21.1	70.4	8.5
	Office 1	1.4	15.8	14%	46.0	51.3	2.8	2.5	32.5	29%	26.2	68.4	5.4	2.4	32.8	28%	25.6	69.6	4.8	3.1	42.9	41%	21.8	70.6	7.6
	Office 2	1.4	13.2	10%	54.1	43.7	2.2	2.5	27.1	20%	36.0	59.6	4.4	2.4	27.3	16%	35.4	60.8	3.8	3.1	35.9	30%	31.8	62.1	6.1
	South facing window																								
	School	1.4	22.0	20%	40.3	54.3	5.4	2.5	44.0	42%	24.2	65.1	10.7	2.4	45.3	45%	23.6	67.1	9.3	3.1	55.2	61%	20.5	64.7	14.8
	Office 1	1.4	21.1	19%	41.3	53.6	5.1	2.5	42.3	40%	24.7	65.2	10.0	2.4	43.4	43%	24.2	67.0	8.7	3.1	53.5	57%	20.8	65.3	13.9
	Office 2	1.4	16.6	11%	51.2	45.0	3.8	2.5	33.5	24%	36.0	56.4	7.6	2.4	34.2	20%	35.6	57.8	6.6	3.1	42.6	34%	32.0	57.4	10.5
	West facing window																								
	School	1.4	12.8	12%	48.8	49.9	1.4	2.5	27.4	25%	27.8	69.4	2.8	2.4	27.0	22%	27.4	70.4	2.2	3.1	37.7	37%	23.3	72.7	4.1
	Office 1	1.4	13.9	12%	48.4	49.6	1.9	2.5	29.0	26%	27.9	68.2	3.9	2.4	28.9	23%	27.5	69.2	3.3	3.1	39.0	37%	23.2	71.3	5.4
	Office 2	1.4	12.2	7%	56.3	41.7	2.0	2.5	25.0	15%	38.4	57.7	3.9	2.4	25.0	11%	38.1	58.5	3.4	3.1	33.1	22%	34.0	60.7	5.4
Side-lit, courtyard	North facing window																								
	School	1.5	9.6	10%	64.2	35.4	0.4	2.7	18.5	19%	39.4	59.8	0.8	2.5	17.9	16%	39.3	60.3	0.4	3.3	24.3	26%	33.5	65.4	1.2
	Office 1	1.5	9.4	10%	64.7	34.9	0.4	2.7	18.1	18%	40.0	59.2	0.8	2.5	17.5	15%	39.9	59.6	0.4	3.3	23.9	25%	34.0	64.8	1.2
	Office 2	1.5	7.8	7%	70.4	29.3	0.3	2.7	15.0	13%	49.4	50.0	0.7	2.5	14.4	10%	49.4	50.3	0.3	3.3	19.7	17%	43.9	55.1	1.0
	East facing window																								
	School	1.5	14.2	13%	58.8	37.4	3.7	2.6	26.1	25%	36.2	56.8	6.9	2.5	26.2	25%	36.0	57.8	6.1	3.2	32.6	33%	31.0	60.2	8.8
	Office 1	1.5	13.5	13%	59.9	36.8	3.3	2.6	24.9	24%	37.2	56.7	6.1	2.5	24.9	22%	37.0	57.5	5.5	3.2	31.2	31%	31.8	60.4	7.8
	Office 2	1.5	11.2	9%	66.0	31.4	2.6	2.6	20.7	18%	46.1	49.1	4.8	2.5	20.6	15%	45.9	49.8	4.2	3.2	26.0	24%	41.0	52.8	6.2
	South facing window																								
	School	1.5	17.0	17%	55.3	39.1	5.7	2.6	30.9	32%	33.8	55.8	10.4	2.5	31.2	33%	33.8	56.7	9.6	3.3	37.7	42%	29.1	57.6	13.2
	Office 1	1.5	16.4	16%	56.2	38.5	5.4	2.6	29.9	31%	34.6	55.6	9.9	2.5	30.1	31%	34.6	56.4	9.0	3.3	36.5	41%	29.8	57.7	12.5
	Office 2	1.5	13.1	11%	64.0	31.9	4.1	2.6	23.8	20%	45.3	47.1	7.5	2.5	23.8	17%	45.4	47.8	6.8	3.3	29.2	27%	40.8	49.7	9.5
	West facing window																								
	School	1.5	11.4	11%	62.3	35.8	1.9	2.6	21.5	21%	38.9	57.5	3.6	2.5	21.0	19%	39.0	58.0	3.0	3.3	27.2	29%	33.2	62.1	4.7
	Office 1	1.5	12.0	11%	61.7	35.8	2.5	2.6	22.5	22%	38.8	56.5	4.7	2.5	22.1	20%	38.8	57.1	4.1	3.3	28.2	29%	33.2	60.8	6.0
	Office 2	1.5	10.4	7%	67.5	30.1	2.4	2.6	19.3	15%	48.0	47.5	4.4	2.5	19.1	12%	48.1	47.9	3.9	3.3	24.2	20%	43.0	51.3	5.6

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Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																								
	School	0.8	5.0	1%	78.5	20.3	1.1	4.0	27.4	30%	39.9	52.1	8.0	3.8	33.0	26%	24.9	68.8	6.3	6.3	43.8	52%	22.9	63.6	13.5
	Office 1	0.8	4.9	1%	78.7	20.2	1.1	4.0	27.1	28%	40.1	52.1	7.7	3.8	32.4	23%	25.3	68.7	6.1	6.3	43.2	51%	22.9	64.0	13.1
	Office 2	0.8	3.9	0%	82.2	17.0	0.8	4.0	22.3	19%	48.7	45.2	6.1	3.8	26.2	4%	36.3	58.9	4.8	6.3	35.7	35%	33.4	56.2	10.4
	Horizontal rooflight North-south																								
	School	0.8	5.0	1%	78.1	20.8	1.1	4.0	27.8	28%	39.5	52.4	8.0	3.8	33.2	25%	24.8	68.9	6.3	6.3	44.2	49%	22.9	63.6	13.6
	Office 1	0.8	4.8	1%	78.5	20.4	1.1	4.0	27.2	27%	39.9	52.3	7.8	3.8	32.5	22%	25.1	68.8	6.0	6.3	43.4	47%	22.8	63.9	13.3
	Office 2	0.8	3.9	0%	82.3	16.9	0.8	4.0	22.3	19%	49.0	44.9	6.1	3.8	26.2	3%	36.3	59.0	4.6	6.3	35.7	34%	33.5	56.2	10.4

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Table C.3 Large room, 300 lux target maintained illuminance: Results for whole room for average daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																								
	School	1.9	21.2	21%	48.7	50.6	0.7	3.3	44.6	43%	26.6	71.7	1.6	3.2	45.1	45%	26.3	72.8	0.9	4.1	56.1	59%	22.4	75.0	2.6
	Office 1	1.9	20.9	21%	49.3	50.0	0.7	3.3	43.9	42%	27.2	71.2	2.6	3.2	44.4	45%	26.8	72.2	2.6	4.1	55.3	57%	22.7	74.7	2.6
	Office 2	1.9	17.5	16%	56.8	42.7	0.6	3.3	36.8	32%	37.3	61.4	1.4	3.2	37.0	33%	36.9	62.3	0.8	4.1	46.7	44%	33.0	64.9	2.1
	East facing window																								
	School	1.9	30.1	28%	41.4	54.0	4.6	3.3	54.7	58%	23.7	67.3	9.1	3.1	55.7	60%	23.1	68.8	8.1	4.1	63.7	81%	20.0	67.8	12.3
	Office 1	1.9	28.6	26%	43.0	52.8	4.1	3.3	52.7	54%	24.6	67.3	8.1	3.1	53.5	56%	24.1	68.7	7.2	4.1	61.9	74%	20.6	68.4	11.0
	Office 2	1.9	24.1	20%	51.5	45.2	3.3	3.3	44.6	41%	34.4	59.1	6.4	3.1	45.2	44%	33.9	60.4	5.8	4.1	53.0	56%	30.6	60.6	8.8
	South facing window																								
	School	1.9	36.4	36%	37.5	55.1	7.4	3.3	61.1	79%	22.8	62.9	14.3	3.1	62.5	86%	22.3	64.5	13.2	4.1	67.7	98%	19.5	61.2	19.2
	Office 1	1.9	35.4	34%	38.4	54.6	7.0	3.3	60.0	77%	23.3	63.1	13.6	3.1	61.3	80%	22.8	64.7	12.5	4.1	66.7	97%	19.8	62.0	18.2
	Office 2	1.9	28.5	22%	48.6	46.1	5.3	3.3	48.9	46%	34.5	55.1	10.5	3.1	49.9	49%	34.1	56.4	9.5	4.1	55.2	63%	30.9	55.1	14.0
	West facing window																								
	School	1.9	25.4	24%	45.7	51.8	2.5	3.3	31.5	30%	26.2	68.8	5.0	3.1	49.6	52%	25.8	69.9	4.3	4.1	59.0	68%	22.1	70.9	7.0
	Office 1	1.9	26.4	24%	45.3	51.5	3.1	3.3	49.5	49%	26.2	67.6	6.1	3.1	50.2	53%	25.8	68.7	5.5	4.1	59.2	68%	21.9	69.6	8.4
	Office 2	1.9	22.5	17%	53.6	43.5	2.9	3.3	41.8	35%	36.7	57.5	5.8	3.1	42.3	37%	36.4	58.4	5.2	4.1	49.8	48%	32.6	59.6	7.9
Side-lit, linear obstruction	North facing window																								
	School	1.6	16.2	17%	61.7	37.8	0.5	2.7	31.8	33%	37.1	61.7	1.2	2.6	32.4	35%	36.4	62.9	0.7	3.4	41.2	44%	31.1	67.0	1.9
	Office 1	1.6	15.9	17%	62.3	37.1	0.5	2.7	31.1	32%	37.8	61.0	1.2	2.6	31.8	35%	37.1	62.2	0.7	3.4	40.3	43%	31.6	66.4	1.9
	Office 2	1.6	13.3	13%	68.5	31.1	0.4	2.7	25.9	25%	47.5	51.5	1.0	2.6	26.4	26%	46.9	52.5	0.6	3.4	33.6	34%	41.7	56.7	1.6
	East facing window																								
	School	1.6	20.8	28%	57.2	39.0	3.8	2.7	38.0	40%	35.4	57.2	7.3	2.6	38.8	43%	34.9	58.5	6.5	3.4	46.5	50%	29.3	61.6	9.1
	Office 1	1.6	20.0	26%	58.1	38.5	3.4	2.7	36.8	38%	36.2	57.3	6.5	2.6	37.5	41%	35.7	58.5	5.8	3.4	45.3	49%	30.4	60.9	8.7
	Office 2	1.6	16.7	20%	64.7	32.6	2.6	2.7	30.8	30%	45.4	49.6	5.1	2.6	31.4	33%	44.9	50.6	4.5	3.4	38.2	40%	40.0	53.3	6.7
	South facing window																								
	School	1.6	23.1	24%	54.3	39.8	5.8	2.7	41.6	45%	34.2	54.8	11.0	2.6	42.3	49%	33.7	56.1	10.3	3.4	49.8	56%	29.0	56.6	14.3
	Office 1	1.6	22.6	24%	55.2	39.2	5.6	2.7	40.6	44%	34.9	54.6	10.5	2.6	41.3	48%	34.3	55.9	9.8	3.4	48.6	55%	29.5	56.8	13.7
	Office 2	1.6	18.3	17%	63.1	32.6	4.3	2.7	33.0	32%	45.4	46.5	8.0	2.6	33.6	36%	44.9	47.6	7.5	3.4	39.8	43%	40.2	49.2	10.5
	West facing window																								
	School	1.5	18.1	19%	60.2	37.7	2.1	2.7	33.9	36%	37.3	58.5	4.2	2.6	34.4	39%	36.9	59.5	3.6	3.4	42.3	47%	31.6	62.8	5.7
	Office 1	1.5	18.6	19%	59.8	37.5	2.7	2.7	34.6	36%	37.4	57.4	5.2	2.6	35.1	39%	36.9	58.5	4.6	3.4	42.9	47%	31.6	61.4	6.9
	Office 2	1.5	15.8	14%	66.1	31.5	2.4	2.7	29.4	27%	46.8	48.5	4.7	2.6	29.8	28%	46.4	49.3	4.3	3.4	36.3	37%	41.5	52.2	6.2

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Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																								
	School	1.4	18.7	18%	51.6	48.4	0.1	2.5	40.7	38%	28.5	71.3	0.2	2.4	41.1	39%	27.9	72.0	0.1	3.1	53.1	54%	23.7	76.0	0.4
	Office 1	1.4	18.3	18%	52.2	47.8	0.0	2.5	39.9	37%	29.2	70.6	0.2	2.4	40.3	38%	28.6	71.3	0.1	3.1	52.2	53%	24.1	75.6	0.4
	Office 2	1.4	15.2	13%	59.4	40.5	0.0	2.5	33.3	27%	39.2	60.7	0.1	2.4	33.4	24%	38.8	61.2	0.1	3.1	43.7	38%	34.3	65.4	0.3
	East facing window																								
	School	1.4	27.1	25%	44.3	52.6	3.1	2.5	51.4	52%	25.1	68.8	6.1	2.4	52.5	55%	24.4	70.2	5.4	3.1	61.0	74%	21.1	70.4	8.5
	Office 1	1.4	25.7	23%	46.0	51.3	2.8	2.5	49.2	48%	26.2	68.4	5.4	2.4	50.2	51%	25.6	69.6	4.8	3.1	59.1	69%	21.8	70.6	7.6
	Office 2	1.4	21.6	17%	54.1	43.7	2.2	2.5	41.5	36%	36.0	59.6	4.4	2.4	42.2	37%	35.4	60.8	3.8	3.1	50.4	51%	31.8	62.1	6.1
	South facing window																								
	School	1.4	33.0	32%	40.3	54.3	5.4	2.5	58.2	75%	24.2	65.1	10.7	2.4	59.9	80%	23.6	67.1	9.3	3.1	65.7	97%	20.5	64.7	14.8
	Office 1	1.4	32.0	30%	41.3	53.6	5.1	2.5	56.9	71%	24.7	65.2	10.0	2.4	58.6	72%	24.2	67.0	8.7	3.1	64.6	97%	20.8	65.3	13.9
	Office 2	1.4	25.5	19%	51.2	45.0	3.8	2.5	46.1	40%	36.0	56.4	7.6	2.4	47.3	43%	35.6	57.8	6.6	3.1	53.1	58%	32.0	57.4	10.5
	West facing window																								
	School	1.4	22.6	21%	48.8	49.9	1.4	2.5	45.4	44%	27.8	69.4	2.8	2.4	46.0	47%	27.4	70.4	2.2	3.1	56.3	63%	23.3	72.7	4.1
	Office 1	1.4	23.5	21%	48.4	49.6	1.9	2.5	46.1	45%	27.9	68.2	3.9	2.4	46.8	47%	27.5	69.2	3.3	3.1	56.4	64%	23.2	71.3	5.4
	Office 2	1.4	20.1	14%	56.3	41.7	2.0	2.5	38.8	30%	38.4	57.7	3.9	2.4	39.3	29%	38.1	58.5	3.4	3.1	47.2	43%	34.0	60.7	5.4
Side-lit, courtyard	North facing window																								
	School	1.5	15.5	16%	64.2	35.4	0.4	2.7	29.5	31%	39.4	59.8	0.8	2.5	29.5	32%	39.3	60.3	0.4	3.3	37.4	40%	33.5	65.4	1.2
	Office 1	1.5	15.3	16%	64.7	34.9	0.4	2.7	29.0	30%	40.0	59.2	0.8	2.5	29.0	31%	39.9	59.6	0.4	3.3	36.7	39%	34.0	64.8	1.2
	Office 2	1.5	12.7	12%	70.4	29.3	0.3	2.7	24.1	23%	49.4	50.0	0.7	2.5	24.0	20%	49.4	50.3	0.3	3.3	30.5	30%	43.9	55.1	1.0
	East facing window																								
	School	1.5	20.5	20%	58.8	37.4	3.7	2.6	37.4	38%	36.2	56.8	6.9	2.5	37.6	39%	36.0	57.8	6.1	3.2	44.9	47%	31.0	60.2	8.8
	Office 1	1.5	19.7	19%	59.9	36.8	3.3	2.6	36.0	36%	37.2	56.7	6.1	2.5	36.1	37%	37.0	57.5	5.5	3.2	43.5	45%	31.8	60.4	7.8
	Office 2	1.5	16.5	15%	66.0	31.4	2.6	2.6	30.2	29%	46.1	49.1	4.8	2.5	30.3	29%	45.9	49.8	4.2	3.2	36.7	38%	41.0	52.8	6.2
	South facing window																								
	School	1.5	23.8	24%	55.3	39.1	5.7	2.6	42.5	45%	33.8	55.8	10.4	2.5	42.5	48%	33.8	56.7	9.6	3.3	50.0	55%	29.1	57.6	13.2
	Office 1	1.5	23.2	24%	56.2	38.5	5.4	2.6	41.3	43%	34.6	55.6	9.9	2.5	41.2	47%	34.6	56.4	9.0	3.3	48.7	54%	29.8	57.7	12.5
	Office 2	1.5	18.7	17%	64.0	31.9	4.1	2.6	33.4	31%	45.3	47.1	7.5	2.5	33.2	32%	45.4	47.8	6.8	3.3	39.5	40%	40.8	49.7	9.5
	West facing window																								
	School	1.5	17.5	18%	62.3	35.8	1.9	2.6	32.4	33%	38.9	57.5	3.6	2.5	32.3	34%	39.0	58.0	3.0	3.3	39.7	43%	33.2	62.1	4.7
	Office 1	1.5	18.1	18%	61.7	35.8	2.5	2.6	33.3	33%	38.8	56.5	4.7	2.5	33.2	34%	38.8	57.1	4.1	3.3	40.5	43%	33.2	60.8	6.0
	Office 2	1.5	15.5	13%	67.5	30.1	2.4	2.6	28.4	26%	48.0	47.5	4.4	2.5	28.3	24%	48.1	47.9	3.9	3.3	34.4	33%	43.0	51.3	5.6

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Scenario	Usage	Large room, small glazed area						Large room, intermediate glazed area, single opening						Large room, intermediate glazed area, multiple openings						Large room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																								
	School	0.8	8.6	6%	78.5	20.3	1.1	4.0	37.7	43%	39.9	52.1	8.0	3.8	49.3	60%	24.9	68.8	6.3	6.3	56.7	69%	22.9	63.6	13.5
	Office 1	0.8	8.5	6%	78.7	20.2	1.1	4.0	37.3	42%	40.1	52.1	7.7	3.8	48.5	58%	25.3	68.7	6.1	6.3	56.2	68%	22.9	64.0	13.1
	Office 2	0.8	6.9	2%	82.2	17.0	0.8	4.0	31.2	33%	48.7	45.2	6.1	3.8	39.8	35%	36.3	58.9	4.8	6.3	47.1	56%	33.4	56.2	10.4
	Horizontal rooflight North-south																								
	School	0.8	8.6	6%	78.1	20.8	1.1	4.0	38.3	44%	39.5	52.4	8.0	3.8	49.8	57%	24.8	68.9	6.3	6.3	57.0	71%	22.9	63.6	13.6
	Office 1	0.8	8.4	6%	78.5	20.4	1.1	4.0	37.7	43%	39.9	52.3	7.8	3.8	48.8	55%	25.1	68.8	6.0	6.3	56.4	71%	22.8	63.9	13.3
	Office 2	0.8	6.8	2%	82.3	16.9	0.8	4.0	31.2	32%	49.0	44.9	6.1	3.8	40.0	35%	36.3	59.0	4.6	6.3	35.7	34%	33.5	56.2	10.4

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Table C.4 Small room, 500 lux target maintained illuminance: Results for whole room for average daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																		
	School	2.4	13.9	8%	30.6	69.4	0.0	4.3	36.8	39%	21.1	78.5	0.5	5.5	49.2	51%	18.4	79.5	2.1
	Office 1	2.4	13.7	8%	31.3	68.7	0.0	4.3	36.1	38%	21.3	78.2	0.5	5.5	48.4	50%	18.3	79.5	2.1
	Office 2	2.4	11.3	2%	41.5	58.5	0.0	4.3	29.9	22%	31.7	67.9	0.4	5.5	40.2	35%	28.7	69.6	1.8
	East facing window																		
	School	2.4	29.1	21%	26.0	68.5	5.4	4.3	50.7	54%	18.8	69.6	11.6	5.5	59.4	71%	16.7	66.7	16.6
	Office 1	2.4	26.9	17%	27.3	67.9	4.8	4.3	48.3	50%	19.3	70.4	10.3	5.5	57.3	65%	16.8	68.4	14.8
	Office 2	2.4	22.3	7%	37.1	59.2	3.7	4.3	40.4	36%	29.3	62.4	8.3	5.5	48.4	49%	26.8	61.1	12.0
	South facing window																		
	School	2.4	40.3	35%	24.7	65.4	9.8	4.3	59.5	72%	18.4	60.9	20.6	5.5	65.0	98%	16.5	56.0	27.5
	Office 1	2.4	38.3	32%	25.4	65.6	9.0	4.3	57.9	69%	18.4	62.4	19.1	5.5	63.8	95%	16.3	57.9	25.8
	Office 2	2.4	29.9	11%	37.1	56.2	6.7	4.3	46.4	43%	29.7	55.8	14.5	5.5	51.9	57%	27.2	53.2	19.7
	West facing window																		
	School	2.4	20.3	14%	29.4	68.6	2.0	4.3	42.7	45%	20.8	74.0	5.2	5.4	53.1	58%	18.2	73.2	8.5
	Office 1	2.4	22.5	14%	29.4	67.3	3.3	4.3	60.6	75%	20.8	74.0	5.2	5.4	53.5	58%	17.7	71.1	11.1
	Office 2	2.4	19.9	5%	40.0	56.4	3.5	4.3	36.9	28%	31.4	61.0	7.7	5.4	44.8	41%	28.4	60.8	10.8
Side-lit, linear obstruction	North facing window																		
	School	1.7	8.7	4%	44.6	55.4	0.0	3.0	23.9	22%	31.3	68.6	0.1	3.8	32.1	32%	27.1	72.2	0.8
	Office 1	1.7	8.5	4%	45.5	54.5	0.0	3.0	23.3	22%	31.8	68.1	0.1	3.8	31.3	31%	27.5	71.7	0.7
	Office 2	1.7	6.8	0%	55.0	45.0	0.0	3.0	18.9	10%	31.7	67.9	0.1	3.8	25.4	21%	28.7	69.6	0.6
	East facing window																		
	School	1.7	15.7	8%	43.4	53.4	3.1	3.1	30.1	30%	30.8	62.7	6.4	3.9	37.3	40%	26.8	64.1	9.1
	Office 1	1.7	14.7	8%	44.1	53.1	2.8	3.1	29.1	30%	31.3	62.9	5.7	3.9	36.1	39%	27.2	64.7	8.1
	Office 2	1.7	11.7	3%	52.9	45.0	2.1	3.1	23.8	18%	41.4	54.4	4.3	3.9	29.7	25%	37.5	56.5	6.0
	South facing window																		
	School	1.7	20.4	14%	42.1	51.9	6.1	3.1	34.4	39%	30.6	58.3	11.1	3.9	41.2	47%	26.8	59.0	14.1
	Office 1	1.7	19.4	14%	42.9	51.5	5.6	3.1	33.2	36%	31.1	58.6	10.4	3.9	40.0	43%	27.1	59.5	13.3
	Office 2	1.7	15.1	3%	53.0	42.8	4.2	3.1	26.4	21%	41.8	50.4	7.8	3.9	32.1	30%	37.9	52.0	10.1
	West facing window																		
	School	1.7	12.0	7%	44.6	53.9	1.6	3.1	26.3	26%	31.7	64.9	3.4	3.8	33.9	35%	27.6	67.3	5.1
	Office 1	1.7	13.0	7%	44.9	52.8	2.4	3.1	26.9	26%	32.1	63.3	4.6	3.8	34.2	35%	27.8	65.6	6.6
	Office 2	1.7	10.9	5%	54.0	43.9	2.1	3.1	22.3	13%	42.2	53.4	4.3	3.8	28.5	22%	38.2	55.9	5.9

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Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																		
	School	1.7	8.2	2%	34.3	65.7	0.0	3.1	29.3	27%	23.4	76.6	0.0	4.1	43.1	43%	20.0	79.8	0.1
	Office 1	1.7	8.1	2%	35.2	64.8	0.0	3.1	28.7	26%	23.8	76.2	0.0	4.1	42.2	41%	20.2	79.7	0.2
	Office 2	1.7	6.7	0%	45.2	54.8	0.0	3.1	23.6	9%	34.3	65.7	0.0	4.1	34.9	24%	30.6	69.2	0.1
	East facing window																		
	School	1.7	22.0	13%	29.3	67.0	3.7	3.1	44.5	44%	20.7	71.1	8.1	4.1	54.8	60%	18.1	69.7	12.2
	Office 1	1.7	20.2	7%	30.8	65.9	3.3	3.1	42.1	39%	21.5	71.3	7.2	4.1	52.4	56%	18.4	70.8	10.8
	Office 2	1.7	16.7	3%	40.4	57.0	2.5	3.1	35.1	25%	31.5	62.7	5.8	4.1	44.0	41%	28.5	62.7	8.9
	South facing window																		
	School	1.7	32.1	20%	27.6	65.9	6.6	3.1	54.8	63%	20.2	64.8	15.0	4.1	61.6	86%	17.8	60.6	21.7
	Office 1	1.7	30.3	19%	28.5	65.5	6.0	3.1	52.9	59%	20.5	65.7	13.8	4.1	60.2	81%	17.6	62.1	20.2
	Office 2	1.7	23.4	5%	40.1	55.4	4.5	3.1	41.8	29%	31.9	57.7	10.4	4.1	48.5	47%	28.8	55.9	15.2
	West facing window																		
	School	1.7	14.0	5%	32.8	66.2	1.0	3.1	36.4	33%	22.9	74.3	2.9	4.1	47.9	50%	19.8	74.9	5.4
	Office 1	1.7	16.2	6%	33.0	64.9	2.1	3.1	37.7	34%	22.8	72.4	4.8	4.1	48.5	52%	19.5	72.8	7.7
	Office 2	1.7	14.8	0%	43.4	54.2	2.4	3.1	31.9	14%	33.7	60.9	5.5	4.1	40.6	30%	30.3	61.8	8.0
Side-lit, courtyard	North facing window																		
	School	1.8	7.7	3%	46.5	53.5	0.0	3.1	22.1	19%	32.6	67.3	0.1	3.9	29.9	30%	27.8	71.8	0.4
	Office 1	1.8	7.5	3%	47.3	52.7	0.0	3.1	21.6	19%	33.0	66.9	0.1	3.9	29.1	29%	28.1	71.5	0.4
	Office 2	1.8	6.1	0%	56.4	43.6	0.0	3.1	17.6	9%	43.4	56.6	0.1	3.9	23.8	16%	38.7	61.0	0.3
	East facing window																		
	School	1.8	17.5	8%	41.4	54.5	4.0	3.2	32.1	29%	29.9	62.4	7.6	4.0	39.2	41%	26.0	63.6	10.4
	Office 1	1.8	16.3	7%	42.5	53.9	3.5	3.2	30.6	29%	30.6	62.6	6.8	4.0	37.7	39%	26.5	64.2	9.3
	Office 2	1.8	13.0	3%	51.4	45.9	2.7	3.2	25.2	17%	40.3	54.6	5.2	4.0	31.1	24%	36.5	56.5	6.9
	South facing window																		
	School	1.8	22.9	14%	38.9	54.4	6.8	3.2	38.5	40%	28.3	59.4	12.4	3.9	45.6	48%	24.7	59.4	15.9
	Office 1	1.8	21.7	13%	40.2	53.7	6.2	3.2	36.8	36%	28.9	59.7	11.5	3.9	43.8	46%	25.1	60.2	14.8
	Office 2	1.8	16.8	3%	50.9	44.5	4.6	3.2	29.0	19%	40.3	51.2	8.5	3.9	34.8	30%	36.4	52.5	11.1
	West facing window																		
	School	1.8	11.5	6%	45.5	53.0	1.6	3.2	26.1	25%	31.8	64.9	3.3	3.9	33.1	32%	27.9	67.3	4.8
	Office 1	1.8	12.9	6%	45.4	52.1	2.7	3.2	27.3	25%	31.9	63.2	5.0	3.9	34.0	32%	27.8	65.4	6.8
	Office 2	1.8	11.6	2%	54.1	43.3	2.7	3.2	23.2	10%	42.1	52.8	5.1	3.9	28.9	22%	38.2	55.0	6.8

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Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥ 50	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																		
	School	0.6	0.9	0%	78.2	21.3	0.6	2.9	21.0	0%	28.3	69.7	2.0	4.2	38.0	0%	22.3	74.5	3.2
	Office 1	0.6	0.8	0%	78.9	20.7	0.4	2.9	20.3	0%	29.1	69.0	1.9	4.2	37.1	0%	22.4	74.5	3.1
	Office 2	0.6	0.6	0%	83.3	16.4	0.4	2.9	15.8	0%	40.6	58.0	1.4	4.2	29.5	0%	33.9	63.7	2.4
	Horizontal rooflight North-south																		
	School	0.6	1.3	0%	78.2	21.1	0.7	2.9	21.6	0%	28.3	68.5	3.2	4.2	38.6	0%	22.2	72.7	5.1
	Office 1	0.6	1.1	0%	78.8	20.6	0.6	2.9	20.8	0%	29.1	68.1	2.8	4.2	37.7	0%	22.4	73.1	4.5
	Office 2	0.6	0.9	0%	83.5	16.1	0.5	2.9	16.2	0%	40.6	57.3	2.1	4.2	29.9	0%	34.0	62.7	3.4

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Table C.5 Small room, 300 lux target maintained illuminance: Results for whole room for average daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																		
	School	2.4	31.7	30%	30.6	69.4	0.0	4.3	58.1	66%	21.1	78.5	0.5	5.5	65.1	90%	18.4	79.5	2.1
	Office 1	2.4	31.1	28%	31.3	68.7	0.0	4.3	57.2	66%	21.3	78.2	0.5	5.5	64.3	84%	18.3	79.5	2.1
	Office 2	2.4	25.7	16%	41.5	58.5	0.0	4.3	48.0	48%	31.7	67.9	0.4	5.5	54.4	63%	28.7	69.6	1.8
	East facing window																		
	School	2.4	46.5	46%	26.0	68.5	5.4	4.3	65.2	89%	18.8	69.6	11.6	5.5	70.8	100%	16.7	66.7	16.6
	Office 1	2.4	44.1	46%	27.3	67.9	4.8	4.3	63.5	82%	19.3	70.4	10.3	5.5	69.3	100%	16.8	68.4	14.8
	Office 2	2.4	36.9	29%	37.1	59.2	3.7	4.3	54.4	64%	29.3	62.4	8.3	5.5	59.8	82%	26.8	61.1	12.0
	South facing window																		
	School	2.4	56.5	68%	24.7	65.4	9.8	4.3	69.1	100%	18.4	60.9	20.6	5.5	72.9	100%	16.5	56.0	27.5
	Office 1	2.4	54.7	64%	25.4	65.6	9.0	4.3	68.1	100%	18.4	62.4	19.1	5.5	72.1	100%	16.3	57.9	25.8
	Office 2	2.4	43.6	33%	37.1	56.2	6.7	4.3	56.1	69%	29.7	55.8	14.5	5.5	60.3	97%	27.2	53.2	19.7
	West facing window																		
	School	2.4	38.4	35%	29.4	68.6	2.0	4.3	60.6	75%	20.8	74.0	5.2	5.4	67.0	100%	18.2	73.2	8.5
	Office 1	2.4	39.6	35%	29.4	67.3	3.3	4.3	60.7	75%	20.6	72.0	7.4	5.4	66.9	100%	17.7	71.1	11.1
	Office 2	2.4	33.6	21%	40.0	56.4	3.5	4.3	50.9	55%	31.4	61.0	7.7	5.4	56.5	71%	28.4	60.8	10.8
Side-lit, linear obstruction	North facing window																		
	School	1.7	21.1	17%	44.6	55.4	0.0	3.0	40.7	42%	31.3	68.6	0.1	3.8	49.1	51%	27.1	72.2	0.8
	Office 1	1.7	20.6	17%	45.5	54.5	0.0	3.0	39.6	40%	31.8	68.1	0.1	3.8	48.0	50%	27.5	71.7	0.7
	Office 2	1.7	16.7	8%	55.0	45.0	0.0	3.0	32.3	29%	42.4	57.5	0.1	3.8	39.4	39%	38.1	61.3	0.6
	East facing window																		
	School	1.7	27.3	46%	43.4	53.4	3.1	3.1	44.4	48%	30.8	62.7	6.4	3.9	51.8	56%	26.8	64.1	9.1
	Office 1	1.7	26.4	46%	44.1	53.1	2.8	3.1	43.6	47%	31.3	62.9	5.7	3.9	50.9	55%	27.2	64.7	8.1
	Office 2	1.7	21.5	29%	52.9	45.0	2.1	3.1	36.1	33%	41.4	54.4	4.3	3.9	42.5	42%	37.5	56.5	6.0
	South facing window																		
	School	1.7	31.2	28%	42.1	51.9	6.1	3.1	47.5	53%	30.6	58.3	11.1	3.9	54.0	63%	26.8	59.0	14.1
	Office 1	1.7	30.1	28%	42.9	51.5	5.6	3.1	46.2	50%	31.1	58.6	10.4	3.9	52.9	58%	27.1	59.5	13.3
	Office 2	1.7	23.9	15%	53.0	42.8	4.2	3.1	37.4	39%	41.8	50.4	7.8	3.9	43.1	47%	37.9	52.0	10.1
	West facing window																		
	School	1.7	23.7	20%	44.6	53.9	1.6	3.1	41.7	42%	31.7	64.9	3.4	3.8	49.8	52%	27.6	67.3	5.1
	Office 1	1.7	24.3	20%	44.9	52.8	2.4	3.1	41.7	41%	32.1	63.3	4.6	3.8	49.6	51%	27.8	65.6	6.6
	Office 2	1.7	20.3	9%	54.0	43.9	2.1	3.1	34.6	32%	42.2	53.4	4.3	3.8	41.3	41%	38.2	55.9	5.9

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Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																		
	School	1.7	24.8	18%	34.3	65.7	0.0	3.1	52.6	56%	23.4	76.6	0.0	4.1	61.3	77%	20.0	79.8	0.1
	Office 1	1.7	24.3	18%	35.2	64.8	0.0	3.1	51.7	55%	23.8	76.2	0.0	4.1	60.3	76%	20.2	79.7	0.2
	Office 2	1.7	20.0	8%	45.2	54.8	0.0	3.1	43.0	38%	34.3	65.7	0.0	4.1	50.7	54%	30.6	69.2	0.1
	East facing window																		
	School	1.7	39.9	33%	29.3	67.0	3.7	3.1	60.9	77%	20.7	71.1	8.1	4.1	67.6	100%	18.1	69.7	12.2
	Office 1	1.7	37.6	32%	30.8	65.9	3.3	3.1	59.1	72%	21.5	71.3	7.2	4.1	65.9	99%	18.4	70.8	10.8
	Office 2	1.7	31.4	18%	40.4	57.0	2.5	3.1	50.2	54%	31.5	62.7	5.8	4.1	56.6	74%	28.5	62.7	8.9
	South facing window																		
	School	1.7	50.6	54%	27.6	65.9	6.6	3.1	65.7	100%	20.2	64.8	15.0	4.1	70.4	100%	17.8	60.6	21.7
	Office 1	1.7	48.5	50%	28.5	65.5	6.0	3.1	64.5	100%	20.5	65.7	13.8	4.1	69.4	100%	17.6	62.1	20.2
	Office 2	1.7	38.2	21%	40.1	55.4	4.5	3.1	52.7	61%	31.9	57.7	10.4	4.1	57.5	82%	28.8	55.9	15.2
	West facing window																		
	School	1.7	31.2	22%	32.8	66.2	1.0	3.1	56.0	65%	22.9	74.3	2.9	4.1	63.6	94%	19.8	74.9	5.4
	Office 1	1.7	32.9	22%	33.0	64.9	2.1	3.1	56.1	65%	22.8	72.4	4.8	4.1	63.4	96%	19.5	72.8	7.7
	Office 2	1.7	28.1	10%	43.4	54.2	2.4	3.1	46.9	43%	33.7	60.9	5.5	4.1	53.3	61%	30.3	61.8	8.0
Side-lit, courtyard	North facing window																		
	School	1.8	19.3	16%	46.5	53.5	0.0	3.1	38.3	40%	32.6	67.3	0.1	3.9	47.2	50%	27.8	71.8	0.4
	Office 1	1.8	18.9	16%	47.3	52.7	0.0	3.1	37.4	39%	33.0	66.9	0.1	3.9	46.2	48%	28.1	71.5	0.4
	Office 2	1.8	15.4	8%	56.4	43.6	0.0	3.1	30.7	27%	43.4	56.6	0.1	3.9	38.0	38%	38.7	61.0	0.3
	East facing window																		
	School	1.8	29.5	25%	41.4	54.5	4.0	3.2	46.2	48%	29.9	62.4	7.6	4.0	53.3	57%	26.0	63.6	10.4
	Office 1	1.8	28.1	23%	42.5	53.9	3.5	3.2	44.9	48%	30.6	62.6	6.8	4.0	52.0	56%	26.5	64.2	9.3
	Office 2	1.8	23.0	14%	51.4	45.9	2.7	3.2	37.4	35%	40.3	54.6	5.2	4.0	43.5	45%	36.5	56.5	6.9
	South facing window																		
	School	1.8	34.7	32%	38.9	54.4	6.8	3.2	51.5	57%	28.3	59.4	12.4	3.9	57.6	67%	24.7	59.4	15.9
	Office 1	1.8	33.1	29%	40.2	53.7	6.2	3.2	49.8	56%	28.9	59.7	11.5	3.9	56.1	65%	25.1	60.2	14.8
	Office 2	1.8	26.2	15%	50.9	44.5	4.6	3.2	40.0	40%	40.3	51.2	8.5	3.9	45.4	47%	36.4	52.5	11.1
	West facing window																		
	School	1.8	22.8	18%	45.5	53.0	1.6	3.2	41.4	42%	31.8	64.9	3.3	3.9	49.0	52%	27.9	67.3	4.8
	Office 1	1.8	23.9	17%	45.4	52.1	2.7	3.2	41.9	43%	31.9	63.2	5.0	3.9	49.2	52%	27.8	65.4	6.8
	Office 2	1.8	20.6	8%	54.1	43.3	2.7	3.2	35.2	31%	42.1	52.8	5.1	3.9	41.3	40%	38.2	55.0	6.8

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Scenario	Usage	Small room, small glazed area						Small room, intermediate glazed area						Small room, large glazed area					
		DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e	DF	DA	DA≥50	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																		
	School	0.6	2.1	0%	78.2	21.3	0.6	2.9	40.8	16%	28.3	69.7	2.0	4.2	54.7	81%	22.3	74.5	3.2
	Office 1	0.6	1.9	0%	78.9	20.7	0.4	2.9	39.8	5%	29.1	69.0	1.9	4.2	53.9	80%	22.4	74.5	3.1
	Office 2	0.6	1.5	0%	83.3	16.4	0.4	2.9	31.8	0%	40.6	58.0	1.4	4.2	44.1	2%	33.9	63.7	2.4
	Horizontal rooflight North-south																		
	School	0.6	2.5	0%	78.2	21.1	0.7	2.9	41.2	16%	28.3	68.5	3.2	4.2	55.2	86%	22.2	72.7	5.1
	Office 1	0.6	2.3	0%	78.8	20.6	0.6	2.9	40.3	8%	29.1	68.1	2.8	4.2	54.2	85%	22.4	73.1	4.5
	Office 2	0.6	1.8	0%	83.5	16.1	0.5	2.9	32.3	0%	40.6	57.3	2.1	4.2	44.1	2%	34.0	62.7	3.4

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Table C.6 Large room, 500 lux target maintained illuminance: Luminaire row ends average for daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																				
	School	0.2	0.0	93.1	6.9	0.0	0.8	0.0	42.8	57.2	0.0	2.2	17.4	28.6	71.4	0.0	3.9	28.8	24.5	73.3	2.0
	Office 1	0.2	0.0	92.8	7.2	0.0	0.8	0.0	43.8	56.2	0.0	2.2	17.4	29.4	70.6	0.0	3.9	28.7	25.0	72.7	2.2
	Office 2	0.2	0.0	93.5	6.5	0.0	0.8	0.0	53.2	46.8	0.0	2.2	14.3	39.7	60.3	0.0	3.9	23.7	35.1	62.8	2.0
	East facing window																				
	School	0.3	0.0	83.7	16.3	0.0	0.8	0.7	40.6	59.4	0.0	2.1	24.1	27.0	73.0	0.0	3.9	39.4	22.5	69.5	8.0
	Office 1	0.3	0.0	84.9	15.1	0.0	0.8	0.7	42.3	57.7	0.0	2.1	22.7	28.3	71.7	0.0	3.9	37.7	23.1	69.8	7.1
	Office 2	0.3	0.0	87.7	12.3	0.0	0.8	0.4	50.7	49.3	0.0	2.1	19.4	37.4	62.6	0.0	3.9	32.2	32.9	61.4	5.6
	South facing window																				
	School	0.2	0.0	65.2	34.8	0.0	0.8	15.9	32.6	66.6	0.8	2.1	42.4	23.6	69.0	7.3	3.8	53.4	21.1	62.2	17.1
	Office 1	0.2	0.0	68.3	31.7	0.0	0.8	14.0	34.8	64.5	0.6	2.1	39.3	24.8	68.7	6.6	3.8	50.3	21.6	62.8	15.7
	Office 2	0.2	0.0	76.1	23.9	0.0	0.8	10.6	46.0	53.4	0.6	2.1	30.8	36.3	59.0	4.8	3.8	40.2	32.7	55.4	11.7
	West facing window																				
	School	0.2	0.2	76.9	23.1	0.0	0.8	8.8	39.9	59.8	0.3	2.0	26.7	29.0	66.4	4.7	3.8	38.2	24.2	67.7	8.1
	Office 1	0.2	0.1	74.8	25.2	0.0	0.8	10.8	40.1	59.4	0.3	2.0	29.0	29.0	65.1	5.9	3.8	39.7	23.9	66.5	9.5
	Office 2	0.2	0.0	78.9	21.1	0.0	0.8	9.2	50.4	49.4	0.3	2.0	24.9	39.6	55.5	4.9	3.8	34.0	34.6	57.0	8.2
Side-lit, linear obstruction	North facing window																				
	School	0.2	0.0	95.1	4.9	0.0	0.6	0.0	56.6	43.4	0.0	1.7	12.9	38.7	61.3	0.0	3.3	22.8	33.7	64.8	1.5
	Office 1	0.2	0.0	94.8	5.2	0.0	0.6	0.0	57.2	42.8	0.0	1.7	12.9	39.5	60.5	0.0	3.3	22.5	34.0	64.4	1.7
	Office 2	0.2	0.0	95.6	4.4	0.0	0.6	0.0	53.2	46.8	0.0	1.7	10.7	39.7	60.3	0.0	3.3	18.6	35.1	62.8	1.5
	East facing window																				
	School	0.2	0.0	95.3	4.7	0.0	0.5	0.0	59.6	40.4	0.0	1.7	15.4	41.1	58.9	0.0	3.3	26.1	32.6	61.0	6.2
	Office 1	0.2	0.0	95.5	4.5	0.0	0.5	0.0	60.2	39.8	0.0	1.7	14.7	41.7	58.3	0.0	3.3	25.4	33.8	60.3	5.8
	Office 2	0.2	0.0	96.5	3.5	0.0	0.5	0.0	67.3	32.7	0.0	1.7	12.2	50.2	49.8	0.0	3.3	21.5	43.0	52.5	4.8
	South facing window																				
	School	0.2	0.0	90.1	9.9	0.0	0.6	5.5	49.1	50.3	0.6	1.7	26.5	38.7	55.0	6.3	3.3	33.6	31.1	55.5	13.5
	Office 1	0.2	0.0	91.3	8.7	0.0	0.6	5.0	51.3	48.1	0.6	1.7	24.8	40.3	54.1	5.6	3.3	32.0	32.1	55.7	12.3
	Office 2	0.2	0.0	93.5	6.5	0.0	0.6	3.7	61.0	38.7	0.4	1.7	19.3	50.7	45.2	4.3	3.3	26.0	42.8	47.8	9.3
	West facing window																				
	School	0.1	0.0	95.3	4.7	0.0	0.5	4.0	54.8	45.1	0.3	1.7	19.9	42.5	53.4	4.2	3.3	27.4	35.4	57.6	7.1
	Office 1	0.1	0.0	94.7	5.3	0.0	0.5	4.7	54.5	45.3	0.3	1.7	20.9	42.4	52.1	5.4	3.3	28.0	35.4	56.5	8.3
	Office 2	0.1	0.0	96.0	4.0	0.0	0.5	3.6	62.9	36.7	0.1	1.7	17.5	51.3	44.2	4.4	3.3	23.6	45.0	47.8	7.0

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Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																				
	School	0.2	0.0	90.8	9.2	0.0	0.7	0.0	46.9	53.1	0.0	1.6	11.8	31.3	68.7	0.0	3.0	25.4	25.8	74.1	0.1
	Office 1	0.2	0.0	90.7	9.3	0.0	0.7	0.0	47.7	52.3	0.0	1.6	11.9	32.3	67.7	0.0	3.0	25.0	26.2	73.5	0.1
	Office 2	0.2	0.0	92.3	7.7	0.0	0.7	0.0	56.6	43.4	0.0	1.6	9.9	42.6	57.4	0.0	3.0	20.6	36.6	63.2	0.1
	East facing window																				
	School	0.2	0.0	87.5	12.5	0.0	0.7	0.0	44.4	55.6	0.0	1.6	18.7	28.9	71.1	0.0	3.1	34.3	24.0	70.7	5.2
	Office 1	0.2	0.0	88.3	11.7	0.0	0.7	0.0	45.7	54.3	0.0	1.6	17.7	30.3	69.7	0.0	3.1	32.7	24.6	70.4	4.7
	Office 2	0.2	0.0	90.4	9.6	0.0	0.7	0.0	54.0	46.0	0.0	1.6	14.8	39.2	60.8	0.0	3.1	27.8	34.1	61.8	3.9
	South facing window																				
	School	0.2	0.0	70.3	29.7	0.0	0.7	8.9	35.6	64.1	0.0	1.6	36.5	25.1	70.6	4.2	3.0	51.4	21.4	66.1	12.7
	Office 1	0.2	0.0	72.6	27.4	0.0	0.7	7.9	37.8	62.0	0.0	1.6	33.4	26.4	69.8	3.9	3.0	48.7	22.2	66.4	11.6
	Office 2	0.2	0.0	79.1	20.9	0.0	0.7	6.0	48.7	51.1	0.0	1.6	25.8	38.0	59.1	2.7	3.0	38.3	33.5	57.9	8.6
	West facing window																				
	School	0.2	0.0	84.3	15.7	0.0	0.7	5.7	42.8	57.2	0.0	1.6	22.0	30.6	67.1	2.4	3.0	34.5	25.6	69.2	5.2
	Office 1	0.2	0.0	82.5	17.5	0.0	0.7	7.8	43.0	57.0	0.0	1.6	24.6	30.8	65.7	3.6	3.0	36.5	25.7	67.9	6.4
	Office 2	0.2	0.0	85.0	15.0	0.0	0.7	6.4	52.7	47.3	0.0	1.6	21.3	41.6	55.3	3.0	3.0	31.2	36.2	57.7	5.9
Side-lit, courtyard	North facing window																				
	School	0.1	0.0	95.8	4.2	0.0	0.5	0.0	62.3	37.7	0.0	1.7	11.8	40.6	59.4	0.0	3.2	21.6	35.8	63.2	1.0
	Office 1	0.1	0.0	95.5	4.5	0.0	0.5	0.0	63.1	36.9	0.0	1.7	12.1	41.2	58.8	0.0	3.2	21.4	36.2	62.6	1.2
	Office 2	0.1	0.0	96.2	3.8	0.0	0.5	0.0	70.3	29.7	0.0	1.7	9.8	51.1	48.9	0.0	3.2	17.6	45.9	53.1	1.0
	East facing window																				
	School	0.1	0.0	97.3	2.7	0.0	0.5	0.0	60.5	39.5	0.0	1.7	15.6	39.7	60.3	0.0	3.2	26.8	35.1	58.6	6.0
	Office 1	0.1	0.0	97.5	2.5	0.0	0.5	0.0	61.9	38.1	0.0	1.7	14.8	40.5	59.5	0.0	3.2	25.6	35.7	58.7	5.4
	Office 2	0.1	0.0	98.1	1.9	0.0	0.5	0.0	69.2	30.8	0.0	1.7	12.4	48.8	51.2	0.0	3.2	22.0	44.5	51.1	4.3
	South facing window																				
	School	0.1	0.0	97.2	2.8	0.0	0.5	3.6	53.0	46.5	0.6	1.7	26.1	36.0	57.7	6.0	3.2	34.4	31.6	55.3	13.1
	Office 1	0.1	0.0	97.7	2.3	0.0	0.5	3.1	54.8	44.6	0.6	1.7	24.3	37.5	56.9	5.5	3.2	32.8	32.5	55.8	11.8
	Office 2	0.1	0.0	98.2	1.8	0.0	0.5	2.4	64.3	35.4	0.4	1.7	18.9	48.0	47.9	4.2	3.2	26.2	43.2	47.9	8.9
	West facing window																				
	School	0.1	0.0	99.9	0.1	0.0	0.5	2.4	62.7	37.0	0.1	1.7	18.6	44.7	51.4	3.8	3.2	25.7	37.5	56.2	6.3
	Office 1	0.1	0.0	99.5	0.5	0.0	0.5	3.0	61.7	38.0	0.1	1.7	19.8	44.2	50.6	5.2	3.2	27.0	37.2	55.3	7.5
	Office 2	0.1	0.0	99.6	0.4	0.0	0.5	2.1	68.6	31.4	0.1	1.7	17.1	52.7	43.1	4.3	3.2	23.1	46.3	46.8	6.6

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Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																				
	School	0.2	0.0	95.2	4.8	0.0	0.2	0.4	83.0	17.0	0.0	2.0	20.1	31.4	64.1	4.5	0.7	4.7	46.6	53.0	0.6
	Office 1	0.2	0.0	94.8	5.2	0.0	0.2	0.4	84.6	15.4	0.0	2.0	17.9	32.7	63.1	3.9	0.7	4.1	48.4	51.0	0.4
	Office 2	0.2	0.0	95.2	4.8	0.0	0.2	0.2	87.8	12.2	0.0	2.0	13.8	43.6	53.6	3.1	0.7	3.5	57.6	42.0	0.4
	Horizontal rooflight North-south																				
	School	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.1	0.9	0.0	2.1	4.6	35.3	64.7	0.0	0.7	0.0	59.1	40.9	0.0
	Office 1	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.1	0.9	0.0	2.1	4.6	36.1	63.9	0.0	0.7	0.0	59.8	40.2	0.0
	Office 2	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.3	0.7	0.0	2.1	3.9	46.1	53.9	0.0	0.7	0.0	66.7	33.3	0.0

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Table C.7 Large room, 300 lux target maintained illuminance: Luminaire row ends average for daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window																				
	School	0.2	0.0	93.1	6.9	0.0	0.8	7.4	42.8	57.2	0.0	2.2	38.8	28.6	71.4	0.0	3.9	50.8	24.5	73.3	2.0
	Office 1	0.2	0.0	92.8	7.2	0.0	0.8	8.0	43.8	56.2	0.0	2.2	38.6	29.4	70.6	0.0	3.9	50.7	25.0	72.7	2.2
	Office 2	0.2	0.0	93.5	6.5	0.0	0.8	7.5	53.2	46.8	0.0	2.2	32.4	39.7	60.3	0.0	3.9	42.1	35.1	62.8	2.0
	East facing window																				
	School	0.3	0.0	83.7	16.3	0.0	0.8	15.4	40.6	59.4	0.0	2.1	44.1	27.0	73.0	0.0	3.9	57.2	22.5	69.5	8.0
	Office 1	0.3	0.0	84.9	15.1	0.0	0.8	13.7	42.3	57.7	0.0	2.1	42.0	28.3	71.7	0.0	3.9	55.5	23.1	69.8	7.1
	Office 2	0.3	0.0	87.7	12.3	0.0	0.8	11.1	50.7	49.3	0.0	2.1	35.7	37.4	62.6	0.0	3.9	47.7	32.9	61.4	5.6
	South facing window																				
	School	0.2	0.6	65.2	34.8	0.0	0.8	41.2	32.6	66.6	0.8	2.1	59.5	23.6	69.0	7.3	3.8	65.9	21.1	62.2	17.1
	Office 1	0.2	0.6	68.3	31.7	0.0	0.8	37.0	34.8	64.5	0.6	2.1	57.0	24.8	68.7	6.6	3.8	63.7	21.6	62.8	15.7
	Office 2	0.2	0.3	76.1	23.9	0.0	0.8	28.1	46.0	53.4	0.6	2.1	45.3	36.3	59.0	4.8	3.8	51.9	32.7	55.4	11.7
	West facing window																				
	School	0.2	0.8	76.9	23.1	0.0	0.8	8.8	39.9	59.8	0.3	2.0	43.5	29.0	66.4	4.7	3.8	55.6	24.2	67.7	8.1
	Office 1	0.2	0.8	74.8	25.2	0.0	0.8	25.6	40.1	59.4	0.3	2.0	44.6	29.0	65.1	5.9	3.8	56.0	23.9	66.5	9.5
	Office 2	0.2	0.4	78.9	21.1	0.0	0.8	21.5	50.4	49.4	0.3	2.0	37.9	39.6	55.5	4.9	3.8	47.1	34.6	57.0	8.2
Side-lit, linear obstruction	North facing window																				
	School	0.2	0.0	95.1	4.9	0.0	0.6	1.2	56.6	43.4	0.0	1.7	25.3	38.7	61.3	0.0	3.3	36.0	33.7	64.8	1.5
	Office 1	0.2	0.0	94.8	5.2	0.0	0.6	1.4	57.2	42.8	0.0	1.7	24.9	39.5	60.5	0.0	3.3	35.6	34.0	64.4	1.7
	Office 2	0.2	0.0	95.6	4.4	0.0	0.6	1.5	65.3	34.7	0.0	1.7	20.4	49.2	50.8	0.0	3.3	29.6	44.3	54.2	1.5
	East facing window																				
	School	0.2	0.0	95.3	4.7	0.0	0.5	2.8	59.6	40.4	0.0	1.7	27.0	41.1	58.9	0.0	3.3	38.4	32.6	61.0	6.2
	Office 1	0.2	0.0	95.5	4.5	0.0	0.5	2.6	60.2	39.8	0.0	1.7	26.3	41.7	58.3	0.0	3.3	37.5	33.8	60.3	5.8
	Office 2	0.2	0.0	96.5	3.5	0.0	0.5	1.8	67.3	32.7	0.0	1.7	21.9	50.2	49.8	0.0	3.3	32.0	43.0	52.5	4.8
	South facing window																				
	School	0.2	0.0	90.1	9.9	0.0	0.6	16.9	49.1	50.3	0.6	1.7	35.8	38.7	55.0	6.3	3.3	44.6	31.1	55.5	13.5
	Office 1	0.2	0.0	91.3	8.7	0.0	0.6	14.9	51.3	48.1	0.6	1.7	34.2	40.3	54.1	5.6	3.3	43.0	32.1	55.7	12.3
	Office 2	0.2	0.0	93.5	6.5	0.0	0.6	11.2	61.0	38.7	0.4	1.7	27.3	50.7	45.2	4.3	3.3	35.0	42.8	47.8	9.3
	West facing window																				
	School	0.1	0.2	95.3	4.7	0.0	0.5	11.0	54.8	45.1	0.3	1.7	29.6	42.5	53.4	4.2	3.3	37.1	35.4	57.6	7.1
	Office 1	0.1	0.2	94.7	5.3	0.0	0.5	12.1	54.5	45.3	0.3	1.7	30.3	42.4	52.1	5.4	3.3	37.7	35.4	56.5	8.3
	Office 2	0.1	0.2	96.0	4.0	0.0	0.5	9.8	62.9	36.7	0.1	1.7	25.5	51.3	44.2	4.4	3.3	32.0	45.0	47.8	7.0

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Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window																				
	School	0.2	0.0	90.8	9.2	0.0	0.7	5.7	46.9	53.1	0.0	1.6	31.6	31.3	68.7	0.0	3.0	48.0	25.8	74.1	0.1
	Office 1	0.2	0.0	90.7	9.3	0.0	0.7	6.1	47.7	52.3	0.0	1.6	31.8	32.3	67.7	0.0	3.0	47.6	26.2	73.5	0.1
	Office 2	0.2	0.0	92.3	7.7	0.0	0.7	5.4	56.6	43.4	0.0	1.6	26.0	42.6	57.4	0.0	3.0	39.6	36.6	63.2	0.1
	East facing window																				
	School	0.2	0.0	87.5	12.5	0.0	0.7	10.9	44.4	55.6	0.0	1.6	40.2	28.9	71.1	0.0	3.1	53.8	24.0	70.7	5.2
	Office 1	0.2	0.0	88.3	11.7	0.0	0.7	9.4	45.7	54.3	0.0	1.6	38.0	30.3	69.7	0.0	3.1	52.0	24.6	70.4	4.7
	Office 2	0.2	0.0	90.4	9.6	0.0	0.7	7.9	54.0	46.0	0.0	1.6	32.1	39.2	60.8	0.0	3.1	44.6	34.1	61.8	3.9
	South facing window																				
	School	0.2	0.6	70.3	29.7	0.0	0.7	32.8	35.6	64.1	0.0	1.6	56.8	25.1	70.6	4.2	3.0	64.7	21.4	66.1	12.7
	Office 1	0.2	0.6	72.6	27.4	0.0	0.7	29.2	37.8	62.0	0.0	1.6	53.6	26.4	69.8	3.9	3.0	62.8	22.2	66.4	11.6
	Office 2	0.2	0.2	79.1	20.9	0.0	0.7	21.8	48.7	51.1	0.0	1.6	42.2	38.0	59.1	2.7	3.0	51.0	33.5	57.9	8.6
	West facing window																				
	School	0.2	0.6	84.3	15.7	0.0	0.7	18.8	42.8	57.2	0.0	1.6	40.0	30.6	67.1	2.4	3.0	52.4	25.6	69.2	5.2
	Office 1	0.2	0.6	82.5	17.5	0.0	0.7	21.1	43.0	57.0	0.0	1.6	41.3	30.8	65.7	3.6	3.0	53.3	25.7	67.9	6.4
	Office 2	0.2	0.4	85.0	15.0	0.0	0.7	18.1	52.7	47.3	0.0	1.6	34.8	41.6	55.3	3.0	3.0	44.5	36.2	57.7	5.9
Side-lit, courtyard	North facing window																				
	School	0.1	0.0	95.8	4.2	0.0	0.5	0.0	62.3	37.7	0.0	1.7	23.8	40.6	59.4	0.0	3.2	32.6	35.8	63.2	1.0
	Office 1	0.1	0.0	95.5	4.5	0.0	0.5	0.0	63.1	36.9	0.0	1.7	23.4	41.2	58.8	0.0	3.2	32.0	36.2	62.6	1.2
	Office 2	0.1	0.0	96.2	3.8	0.0	0.5	0.0	70.3	29.7	0.0	1.7	19.2	51.1	48.9	0.0	3.2	26.8	45.9	53.1	1.0
	East facing window																				
	School	0.1	0.0	97.3	2.7	0.0	0.5	2.4	60.5	39.5	0.0	1.7	27.6	39.7	60.3	0.0	3.2	37.4	35.1	58.6	6.0
	Office 1	0.1	0.0	97.5	2.5	0.0	0.5	2.2	61.9	38.1	0.0	1.7	26.8	40.5	59.5	0.0	3.2	36.4	35.7	58.7	5.4
	Office 2	0.1	0.0	98.1	1.9	0.0	0.5	1.7	69.2	30.8	0.0	1.7	22.7	48.8	51.2	0.0	3.2	31.2	44.5	51.1	4.3
	South facing window																				
	School	0.1	0.0	97.2	2.8	0.0	0.5	13.7	53.0	46.5	0.6	1.7	37.4	36.0	57.7	6.0	3.2	45.0	31.6	55.3	13.1
	Office 1	0.1	0.0	97.7	2.3	0.0	0.5	12.1	54.8	44.6	0.6	1.7	35.5	37.5	56.9	5.5	3.2	43.4	32.5	55.8	11.8
	Office 2	0.1	0.0	98.2	1.8	0.0	0.5	8.9	64.3	35.4	0.4	1.7	28.2	48.0	47.9	4.2	3.2	35.4	43.2	47.9	8.9
	West facing window																				
	School	0.1	0.0	99.9	0.1	0.0	0.5	7.3	62.7	37.0	0.1	1.7	28.7	44.7	51.4	3.8	3.2	35.8	37.5	56.2	6.3
	Office 1	0.1	0.0	99.5	0.5	0.0	0.5	8.6	61.7	38.0	0.1	1.7	29.6	44.2	50.6	5.2	3.2	36.6	37.2	55.3	7.5
	Office 2	0.1	0.0	99.6	0.4	0.0	0.5	7.3	68.6	31.4	0.1	1.7	25.0	52.7	43.1	4.3	3.2	31.1	46.3	46.8	6.6

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Scenario	Usage	Large room, small glazed area					Large room, intermediate glazed area, single opening					Large room, intermediate glazed area, multiple openings					Large room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West																				
	School	0.2	0.0	95.2	4.8	0.0	0.2	0.8	83.0	17.0	0.0	2.0	36.1	31.4	64.1	4.5	0.7	13.8	46.6	53.0	0.6
	Office 1	0.2	0.0	94.8	5.2	0.0	0.2	0.6	84.6	15.4	0.0	2.0	33.9	32.7	63.1	3.9	0.7	12.4	48.4	51.0	0.4
	Office 2	0.2	0.0	95.2	4.8	0.0	0.2	0.4	87.8	12.2	0.0	2.0	26.7	43.6	53.6	3.1	0.7	10.0	57.6	42.0	0.4
	Horizontal rooflight North-south																				
	School	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.1	0.9	0.0	2.1	23.4	35.3	64.7	0.0	0.7	0.0	59.1	40.9	0.0
	Office 1	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.1	0.9	0.0	2.1	23.1	36.1	63.9	0.0	0.7	0.0	59.8	40.2	0.0
	Office 2	0.0	0.0	100.0	0.0	0.0	0.2	0.0	99.3	0.7	0.0	2.1	19.3	46.1	53.9	0.0	0.7	0.0	66.7	33.3	0.0

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Table C.8 Small room, 500 lux target maintained illuminance: Luminaire row ends average for daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window															
	School	1.6	3.7	35.8	64.2	0.0	4.1	32.3	22.0	78.0	0.0	5.9	45.8	19.2	77.2	3.3
	Office 1	1.6	4.3	36.5	63.5	0.0	4.1	32.0	22.3	77.7	0.0	5.9	45.3	19.2	76.8	3.7
	Office 2	1.6	4.0	46.8	53.2	0.0	4.1	26.7	33.0	66.7	0.0	5.9	37.5	29.7	67.0	3.3
	East facing window															
	School	1.6	10.8	30.3	69.7	0.0	4.0	44.0	20.2	76.5	3.3	5.8	55.3	18.0	68.3	13.8
	Office 1	1.6	9.5	32.3	67.7	0.0	4.0	42.3	20.7	76.3	3.0	5.8	53.2	18.0	69.7	12.2
	Office 2	1.6	8.3	41.3	58.7	0.0	4.0	35.7	30.3	67.0	2.7	5.8	45.0	28.0	62.2	10.2
	South facing window															
	School	1.6	33.5	26.3	66.8	7.3	4.0	59.2	18.7	63.0	18.3	5.9	65.2	16.8	56.0	27.2
	Office 1	1.6	30.0	27.3	66.2	6.0	4.0	56.2	18.7	64.8	16.5	5.9	63.5	17.0	57.8	25.2
	Office 2	1.6	22.7	39.3	55.8	4.5	4.0	44.7	30.3	57.7	12.0	5.9	51.5	27.7	53.0	19.0
	West facing window															
	School	1.6	18.3	32.5	63.3	4.2	4.0	41.7	21.7	69.8	8.2	5.8	52.0	18.8	68.8	12.2
	Office 1	1.6	21.0	32.7	62.8	4.7	4.0	58.8	21.7	69.8	8.2	5.8	53.2	18.3	67.2	14.5
	Office 2	1.6	18.2	43.3	53.2	3.8	4.0	36.3	32.3	58.0	9.7	5.8	44.3	29.0	57.7	13.0
Side-lit, linear obstruction	North facing window															
	School	1.2	2.7	48.3	51.7	0.0	3.1	22.5	33.3	66.7	0.0	4.5	31.7	29.0	69.7	1.3
	Office 1	1.2	3.0	49.3	50.7	0.0	3.1	22.2	33.7	66.3	0.0	4.5	31.0	29.2	69.2	1.7
	Office 2	1.2	3.0	58.7	41.3	0.0	3.1	17.8	33.0	66.7	0.0	4.5	25.5	29.7	67.0	1.3
	East facing window															
	School	1.3	4.7	49.7	50.3	0.0	3.1	26.7	33.3	66.0	0.3	4.4	35.2	29.5	61.7	8.8
	Office 1	1.3	4.3	50.3	49.7	0.0	3.1	26.2	33.7	66.0	0.3	4.4	34.3	29.8	62.3	8.0
	Office 2	1.3	3.3	58.3	41.7	0.0	3.1	21.3	43.2	56.5	0.3	4.4	28.8	39.8	54.5	6.2
	South facing window															
	School	1.3	17.2	44.5	50.2	5.3	3.1	34.3	32.3	55.8	12.0	4.5	40.2	29.5	53.5	17.2
	Office 1	1.3	15.3	46.0	49.3	4.7	3.1	33.0	32.7	56.7	10.7	4.5	39.2	29.5	55.0	15.5
	Office 2	1.3	11.5	55.7	40.8	3.8	3.1	26.2	43.3	48.7	8.0	4.5	31.7	39.8	48.3	11.8
	West facing window															
	School	1.2	12.7	48.5	47.5	3.7	3.0	27.2	33.5	59.8	6.5	4.4	34.3	30.0	61.0	9.0
	Office 1	1.2	14.2	49.0	47.5	3.5	3.0	27.8	34.0	58.2	7.8	4.4	34.2	30.2	59.7	10.3
	Office 2	1.2	11.3	57.3	40.0	2.7	3.0	23.2	44.0	49.2	6.8	4.4	28.5	40.2	51.0	8.8

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Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window															
	School	1.0	0.0	40.5	59.5	0.0	2.8	24.5	25.2	74.8	0.0	4.4	39.3	20.8	79.2	0.3
	Office 1	1.0	0.3	41.5	58.5	0.0	2.8	24.5	25.5	74.5	0.0	4.4	38.7	20.8	78.8	0.3
	Office 2	1.0	0.7	50.8	49.2	0.0	2.8	20.0	36.5	63.5	0.0	4.4	31.8	31.5	68.2	0.3
	East facing window															
	School	1.1	2.7	35.2	64.8	0.0	2.9	37.2	22.3	75.7	2.0	4.4	50.5	18.8	71.7	9.5
	Office 1	1.1	2.7	36.7	63.3	0.0	2.9	35.5	23.3	75.0	1.5	4.4	48.3	19.3	72.3	8.8
	Office 2	1.1	2.8	45.5	54.5	0.0	2.9	29.7	33.0	65.3	1.5	4.4	40.8	29.2	63.5	7.2
	South facing window															
	School	1.1	22.0	30.0	66.5	4.0	2.8	53.3	20.7	66.3	12.7	4.4	61.7	18.2	60.5	21.3
	Office 1	1.1	19.7	31.5	64.8	3.3	2.8	50.3	21.3	67.3	11.3	4.4	59.7	18.2	62.2	19.7
	Office 2	1.1	14.8	43.2	54.2	2.7	2.8	39.7	32.8	58.7	8.5	4.4	47.7	29.0	56.0	14.7
	West facing window															
	School	1.2	12.5	35.7	62.0	2.5	2.9	35.2	23.7	70.7	5.8	4.4	47.3	20.3	71.2	8.7
	Office 1	1.2	15.2	36.0	61.3	2.7	2.9	37.0	23.7	68.3	7.8	4.4	48.5	20.2	69.2	10.7
	Office 2	1.2	14.0	46.3	51.5	2.5	2.9	31.0	34.5	58.0	7.5	4.4	40.7	30.7	59.3	10.0
Side-lit, courtyard	North facing window															
	School	1.1	0.3	52.7	47.3	0.0	3.0	19.8	36.7	63.3	0.0	4.5	30.2	30.2	69.2	0.7
	Office 1	1.1	0.7	53.7	46.3	0.0	3.0	19.2	37.2	62.8	0.0	4.5	29.5	30.5	68.8	0.7
	Office 2	1.1	0.7	62.0	38.0	0.0	3.0	15.7	47.2	52.8	0.0	4.5	24.3	41.0	58.3	0.7
	East facing window															
	School	1.1	1.5	51.2	48.8	0.0	3.0	26.2	34.5	64.3	1.0	4.4	35.2	30.0	61.0	9.2
	Office 1	1.1	1.5	51.8	48.2	0.0	3.0	25.3	35.3	63.7	1.0	4.4	34.3	30.5	61.7	8.0
	Office 2	1.1	1.2	59.8	40.2	0.0	3.0	20.7	44.7	54.7	0.7	4.4	28.5	40.0	54.0	6.0
	South facing window															
	School	1.2	17.2	44.5	50.2	5.2	3.0	36.0	32.5	55.7	11.7	4.4	41.3	28.2	54.7	17.3
	Office 1	1.2	14.8	46.5	49.0	4.8	3.0	34.0	33.3	56.0	10.7	4.4	40.0	28.5	55.5	16.0
	Office 2	1.2	11.3	56.5	40.0	3.5	3.0	26.8	44.0	47.7	8.0	4.4	31.8	39.8	48.2	11.8
	West facing window															
	School	1.1	9.5	52.3	44.3	3.3	3.0	25.2	36.2	58.2	5.7	4.4	32.3	31.0	61.5	7.3
	Office 1	1.1	11.0	52.3	44.0	3.5	3.0	26.0	36.0	56.3	7.3	4.4	33.3	30.8	60.0	9.2
	Office 2	1.1	8.8	60.3	37.0	2.7	3.0	21.7	46.0	47.2	7.0	4.4	28.2	40.7	51.0	8.3

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Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West															
	School	0.9	0.0	67.6	32.4	0.0	2.1	26.3	29.8	61.5	9.0	3.1	39.0	24.0	64.0	12.3
	Office 1	0.9	0.0	66.9	33.1	0.0	2.1	25.2	30.8	61.3	8.2	3.1	37.3	24.5	64.8	10.8
	Office 2	0.9	0.0	67.6	32.4	0.0	2.1	19.5	42.8	51.7	6.2	3.1	28.8	36.5	55.3	8.3
	Horizontal rooflight North-south															
	School	0.4	0.0	82.8	17.2	0.0	2.0	16.3	32.0	63.7	3.8	3.1	32.7	24.0	71.7	4.3
	Office 1	0.4	0.0	84.8	15.2	0.0	2.0	14.7	33.7	63.0	3.3	3.1	30.2	25.0	71.3	3.7
	Office 2	0.4	0.0	88.5	11.5	0.0	2.0	10.8	44.7	52.7	2.7	3.1	23.0	36.7	60.7	2.7

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Table C.9 Small room, 300 lux target maintained illuminance: Luminaire row ends average for daylight factor (DF), daylight autonomy (DA) and useful daylight illuminance (UDI). Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, no obstructions	North facing window															
	School	1.6	22.3	35.8	64.2	0.0	4.1	54.8	22.0	78.0	0.0	5.9	63.2	19.2	77.2	3.3
	Office 1	1.6	22.3	36.5	63.5	0.0	4.1	54.5	22.3	77.7	0.0	5.9	63.2	19.2	76.8	3.7
	Office 2	1.6	18.5	46.8	53.2	0.0	4.1	45.0	33.0	66.7	0.0	5.9	53.2	29.7	67.0	3.3
	East facing window															
	School	1.6	34.3	30.3	69.7	0.0	4.0	61.7	20.2	76.5	3.3	5.8	68.2	18.0	68.3	13.8
	Office 1	1.6	32.7	32.3	67.7	0.0	4.0	60.2	20.7	76.3	3.0	5.8	66.8	18.0	69.7	12.2
	Office 2	1.6	27.2	41.3	58.7	0.0	4.0	51.2	30.3	67.0	2.7	5.8	58.2	28.0	62.2	10.2
	South facing window															
	School	1.6	52.7	26.3	66.8	7.3	4.0	68.8	18.7	63.0	18.3	5.9	73.0	16.8	56.0	27.2
	Office 1	1.6	49.8	27.3	66.2	6.0	4.0	67.3	18.7	64.8	16.5	5.9	71.8	17.0	57.8	25.2
	Office 2	1.6	38.8	39.3	55.8	4.5	4.0	55.3	30.3	57.7	12.0	5.9	59.8	27.7	53.0	19.0
	West facing window															
	School	1.6	34.0	32.5	63.3	4.2	4.0	58.8	21.7	69.8	8.2	5.8	66.5	18.8	68.8	12.2
	Office 1	1.6	35.8	32.7	62.8	4.7	4.0	59.2	21.2	68.3	10.7	5.8	66.5	18.3	67.2	14.5
	Office 2	1.6	30.2	43.3	53.2	3.8	4.0	49.8	32.3	58.0	9.7	5.8	56.2	29.0	57.7	13.0
Side-lit, linear obstruction	North facing window															
	School	1.2	13.5	48.3	51.7	0.0	3.1	37.7	33.3	66.7	0.0	4.5	47.0	29.0	69.7	1.3
	Office 1	1.2	13.7	49.3	50.7	0.0	3.1	37.3	33.7	66.3	0.0	4.5	46.3	29.2	69.2	1.7
	Office 2	1.2	11.2	58.7	41.3	0.0	3.1	30.2	44.2	55.8	0.0	4.5	38.0	39.7	59.0	1.3
	East facing window															
	School	1.3	19.2	49.7	50.3	0.0	3.1	40.0	33.3	66.0	0.3	4.4	48.5	29.5	61.7	8.8
	Office 1	1.3	18.7	50.3	49.7	0.0	3.1	39.3	33.7	66.0	0.3	4.4	47.8	29.8	62.3	8.0
	Office 2	1.3	15.0	58.3	41.7	0.0	3.1	33.0	43.2	56.5	0.3	4.4	40.3	39.8	54.5	6.2
	South facing window															
	School	1.3	28.5	44.5	50.2	5.3	3.1	45.7	32.3	55.8	12.0	4.5	52.0	29.5	53.5	17.2
	Office 1	1.3	26.7	46.0	49.3	4.7	3.1	44.2	32.7	56.7	10.7	4.5	51.2	29.5	55.0	15.5
	Office 2	1.3	21.2	55.7	40.8	3.8	3.1	35.7	43.3	48.7	8.0	4.5	42.0	39.8	48.3	11.8
	West facing window															
	School	1.2	22.5	48.5	47.5	3.7	3.0	39.7	33.5	59.8	6.5	4.4	47.3	30.0	61.0	9.0
	Office 1	1.2	23.0	49.0	47.5	3.5	3.0	39.3	34.0	58.2	7.8	4.4	47.7	30.2	59.7	10.3
	Office 2	1.2	19.2	57.3	40.0	2.7	3.0	33.0	44.0	49.2	6.8	4.4	39.5	40.2	51.0	8.8

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Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Side-lit, overhang	North facing window															
	School	1.0	12.2	40.5	59.5	0.0	2.8	48.2	25.2	74.8	0.0	4.4	59.5	20.8	79.2	0.3
	Office 1	1.0	12.5	41.5	58.5	0.0	2.8	47.5	25.5	74.5	0.0	4.4	58.5	20.8	78.8	0.3
	Office 2	1.0	10.2	50.8	49.2	0.0	2.8	39.5	36.5	63.5	0.0	4.4	49.2	31.5	68.2	0.3
	East facing window															
	School	1.1	26.2	35.2	64.8	0.0	2.9	56.0	22.3	75.7	2.0	4.4	65.2	18.8	71.7	9.5
	Office 1	1.1	24.0	36.7	63.3	0.0	2.9	54.3	23.3	75.0	1.5	4.4	63.7	19.3	72.3	8.8
	Office 2	1.1	20.0	45.5	54.5	0.0	2.9	46.0	33.0	65.3	1.5	4.4	55.0	29.2	63.5	7.2
	South facing window															
	School	1.1	45.7	30.0	66.5	4.0	2.8	64.7	20.7	66.3	12.7	4.4	70.7	18.2	60.5	21.3
	Office 1	1.1	42.0	31.5	64.8	3.3	2.8	63.3	21.3	67.3	11.3	4.4	69.2	18.2	62.2	19.7
	Office 2	1.1	32.0	43.2	54.2	2.7	2.8	51.3	32.8	58.7	8.5	4.4	57.2	29.0	56.0	14.7
	West facing window															
	School	1.2	27.2	35.7	62.0	2.5	2.9	54.5	23.7	70.7	5.8	4.4	63.2	20.3	71.2	8.7
	Office 1	1.2	29.2	36.0	61.3	2.7	2.9	54.7	23.7	68.3	7.8	4.4	63.3	20.2	69.2	10.7
	Office 2	1.2	25.3	46.3	51.5	2.5	2.9	45.8	34.5	58.0	7.5	4.4	53.2	30.7	59.3	10.0
Side-lit, courtyard	North facing window															
	School	1.1	9.2	52.7	47.3	0.0	3.0	34.5	36.7	63.3	0.0	4.5	45.2	30.2	69.2	0.7
	Office 1	1.1	9.2	53.7	46.3	0.0	3.0	33.8	37.2	62.8	0.0	4.5	44.0	30.5	68.8	0.7
	Office 2	1.1	7.7	62.0	38.0	0.0	3.0	27.7	47.2	52.8	0.0	4.5	36.3	41.0	58.3	0.7
	East facing window															
	School	1.1	17.8	51.2	48.8	0.0	3.0	39.5	34.5	64.3	1.0	4.4	48.3	30.0	61.0	9.2
	Office 1	1.1	17.0	51.8	48.2	0.0	3.0	38.2	35.3	63.7	1.0	4.4	47.3	30.5	61.7	8.0
	Office 2	1.1	13.2	59.8	40.2	0.0	3.0	32.0	44.7	54.7	0.7	4.4	39.5	40.0	54.0	6.0
	South facing window															
	School	1.2	28.8	44.5	50.2	5.2	3.0	46.3	32.5	55.7	11.7	4.4	53.3	28.2	54.7	17.3
	Office 1	1.2	26.5	46.5	49.0	4.8	3.0	44.3	33.3	56.0	10.7	4.4	51.7	28.5	55.5	16.0
	Office 2	1.2	20.3	56.5	40.0	3.5	3.0	36.0	44.0	47.7	8.0	4.4	42.2	39.8	48.2	11.8
	West facing window															
	School	1.1	17.7	52.3	44.3	3.3	3.0	37.5	36.2	58.2	5.7	4.4	45.8	31.0	61.5	7.3
	Office 1	1.1	18.7	52.3	44.0	3.5	3.0	38.3	36.0	56.3	7.3	4.4	46.2	30.8	60.0	9.2
	Office 2	1.1	15.8	60.3	37.0	2.7	3.0	31.7	46.0	47.2	7.0	4.4	39.0	40.7	51.0	8.3

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Scenario	Usage	Small room, small glazed area					Small room, intermediate glazed area					Small room, large glazed area				
		DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e	DF	DA	UDI-s	UDI-a	UDI-e
Top-lit	Horizontal rooflight East-West															
	School	0.9	0.0	67.6	32.4	0.0	2.1	40.3	29.8	61.5	9.0	3.1	53.3	24.0	64.0	12.3
	Office 1	0.9	0.0	66.9	33.1	0.0	2.1	39.0	30.8	61.3	8.2	3.1	52.3	24.5	64.8	10.8
	Office 2	0.9	0.0	67.6	32.4	0.0	2.1	30.7	42.8	51.7	6.2	3.1	42.0	36.5	55.3	8.3
	Horizontal rooflight North-south															
	School	0.4	0.7	82.8	17.2	0.0	2.0	33.2	32.0	63.7	3.8	3.1	50.8	24.0	71.7	4.3
	Office 1	0.4	0.7	84.8	15.2	0.0	2.0	31.2	33.7	63.0	3.3	3.1	49.0	25.0	71.3	3.7
	Office 2	0.4	0.7	88.5	11.5	0.0	2.0	24.2	44.7	52.7	2.7	3.1	39.5	36.7	60.7	2.7

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Table C.10 Large room daylight dependency factors (FD), as calculated by the current EN15193:2007 and prEN15193 revised. Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Large room, small glazed area				Large room, intermediate glazed area, single opening				Large room, intermediate glazed area, multiple openings				Large room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Side-lit, no obstructions	North facing window																
	School	0.51	0.57	0.41	0 50	0.36	0.57	0.29	0.49	0.36	0.57	0.29	0.49	0.36	0.56	0.29	0.49
	Office 1	0.51	0.57	0.41	0 50	0.36	0.57	0.29	0.49	0.36	0.57	0.29	0.49	0.36	0.56	0.29	0.49
	Office 2	0.56	0.57	0.50	0 50	0.45	0.57	0.42	0.49	0.45	0.57	0.42	0.49	0.45	0.56	0.42	0.49
	East facing window																
	School	0.51	0.53	0.41	0.47	0.36	0.53	0.29	0.47	0.36	0.53	0.29	0.47	0.36	0.52	0.29	0.46
	Office 1	0.51	0.53	0.41	0.47	0.36	0.53	0.29	0.47	0.36	0.53	0.29	0.47	0.36	0.52	0.29	0.46
	Office 2	0.56	0.53	0.50	0.47	0.45	0.53	0.42	0.47	0.45	0.53	0.42	0.47	0.45	0.52	0.42	0.46
	South facing window																
	School	0.51	0.49	0.41	0.45	0.36	0.49	0.29	0.45	0.36	0.49	0.29	0.45	0.36	0.48	0.29	0.44
	Office 1	0.51	0.49	0.41	0.45	0.36	0.49	0.29	0.45	0.36	0.49	0.29	0.45	0.36	0.48	0.29	0.44
	Office 2	0.56	0.49	0.50	0.45	0.45	0.49	0.42	0.45	0.45	0.49	0.42	0.45	0.45	0.48	0.42	0.44
	West facing window																
	School	0.51	0.53	0.41	0.47	0.36	0.53	0.29	0.47	0.36	0.53	0.29	0.47	0.36	0.52	0.29	0.46
	Office 1	0.51	0.53	0.41	0.47	0.36	0.53	0.29	0.47	0.36	0.53	0.29	0.47	0.36	0.52	0.29	0.46
	Office 2	0.56	0.53	0.50	0.47	0.45	0.53	0.42	0.47	0.45	0.53	0.42	0.47	0.45	0.52	0.42	0.46
Side-lit, linear obstruction	North facing window																
	School	0.51	0.61	0.41	0 54	0.51	0.58	0.41	0.50	0.51	0.58	0.41	0.50	0.36	0.57	0.29	0.49
	Office 1	0.51	0.61	0.41	0 54	0.51	0.58	0.41	0.50	0.51	0.58	0.41	0.50	0.36	0.57	0.29	0.49
	Office 2	0.56	0.61	0.50	0 54	0.56	0.58	0.50	0.50	0.56	0.58	0.50	0.50	0.45	0.57	0.42	0.49
	East facing window																
	School	0.51	0.57	0.41	0 52	0.51	0.54	0.41	0.48	0.51	0.54	0.41	0.48	0.36	0.53	0.29	0.47
	Office 1	0.51	0.57	0.41	0 52	0.51	0.54	0.41	0.48	0.51	0.54	0.41	0.48	0.36	0.53	0.29	0.47
	Office 2	0.56	0.57	0.50	0 52	0.56	0.54	0.50	0.48	0.56	0.54	0.50	0.48	0.45	0.53	0.42	0.47
	South facing window																
	School	0.51	0.54	0.41	0 50	0.51	0.50	0.41	0.45	0.51	0.50	0.41	0.45	0.36	0.49	0.29	0.45
	Office 1	0.51	0.54	0.41	0 50	0.51	0.50	0.41	0.45	0.51	0.50	0.41	0.45	0.36	0.49	0.29	0.45
	Office 2	0.56	0.54	0.50	0 50	0.56	0.50	0.50	0.45	0.56	0.50	0.50	0.45	0.45	0.49	0.42	0.45
	West facing window																
	School	0.51	0.57	0.41	0 52	0.51	0.54	0.41	0.48	0.51	0.54	0.41	0.48	0.36	0.53	0.29	0.47
	Office 1	0.51	0.57	0.41	0 52	0.51	0.54	0.41	0.48	0.51	0.54	0.41	0.48	0.36	0.53	0.29	0.47
	Office 2	0.56	0.57	0.50	0 52	0.56	0.54	0.50	0.48	0.56	0.54	0.50	0.48	0.45	0.53	0.42	0.47

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Scenario	Usage	Large room, small glazed area				Large room, intermediate glazed area, single opening				Large room, intermediate glazed area, multiple openings				Large room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Side-lit, overhang	North facing window																
	School	0.66	0.64	0.52	0 57	0.51	0.63	0.41	0.56	0.51	0.63	0.41	0.56	0.51	0.62	0.41	0.54
	Office 1	0.66	0.64	0.52	0 57	0.51	0.63	0.41	0.56	0.51	0.63	0.41	0.56	0.51	0.62	0.41	0.54
	Office 2	0.68	0.64	0.57	0 57	0.56	0.63	0.50	0.56	0.56	0.63	0.50	0.56	0.56	0.62	0.50	0.54
	East facing window																
	School	0.66	0.60	0.52	0 54	0.51	0.59	0.41	0.54	0.51	0.59	0.41	0.54	0.51	0.58	0.41	0.52
	Office 1	0.66	0.60	0.52	0 54	0.51	0.59	0.41	0.54	0.51	0.59	0.41	0.54	0.51	0.58	0.41	0.52
	Office 2	0.68	0.60	0.57	0 54	0.56	0.59	0.50	0.54	0.56	0.59	0.50	0.54	0.56	0.58	0.50	0.52
	South facing window																
	School	0.66	0.56	0.52	0 52	0.51	0.56	0.41	0.51	0.51	0.56	0.41	0.51	0.51	0.54	0.41	0.51
	Office 1	0.66	0.56	0.52	0 52	0.51	0.56	0.41	0.51	0.51	0.56	0.41	0.51	0.51	0.54	0.41	0.51
	Office 2	0.68	0.56	0.57	0 52	0.56	0.56	0.50	0.51	0.56	0.56	0.50	0.51	0.56	0.54	0.50	0.51
	West facing window																
	School	0.66	0.60	0.52	0 54	0.51	0.59	0.41	0.54	0.51	0.59	0.41	0.54	0.51	0.58	0.41	0.52
	Office 1	0.66	0.60	0.52	0 54	0.51	0.59	0.41	0.54	0.51	0.59	0.41	0.54	0.51	0.58	0.41	0.52
	Office 2	0.68	0.60	0.57	0 54	0.56	0.59	0.50	0.54	0.56	0.59	0.50	0.54	0.56	0.58	0.50	0.52
Side-lit, courtyard	North facing window																
	School	0.51	0.63	0.41	0 56	0.51	0.62	0.41	0.55	0.51	0.62	0.41	0.55	0.51	0.61	0.41	0.54
	Office 1	0.51	0.63	0.41	0 56	0.51	0.62	0.41	0.55	0.51	0.62	0.41	0.55	0.51	0.61	0.41	0.54
	Office 2	0.56	0.63	0.50	0 56	0.56	0.62	0.50	0.55	0.56	0.62	0.50	0.55	0.56	0.61	0.50	0.54
	East facing window																
	School	0.51	0.59	0.41	0 54	0.51	0.58	0.41	0.53	0.51	0.58	0.41	0.53	0.51	0.57	0.41	0.52
	Office 1	0.51	0.59	0.41	0 54	0.51	0.58	0.41	0.53	0.51	0.58	0.41	0.53	0.51	0.57	0.41	0.52
	Office 2	0.56	0.59	0.50	0 54	0.56	0.58	0.50	0.53	0.56	0.58	0.50	0.53	0.56	0.57	0.50	0.52
	South facing window																
	School	0.51	0.56	0.41	0 52	0.51	0.55	0.41	0.51	0.51	0.55	0.41	0.51	0.51	0.54	0.41	0.50
	Office 1	0.51	0.56	0.41	0 52	0.51	0.55	0.41	0.51	0.51	0.55	0.41	0.51	0.51	0.54	0.41	0.50
	Office 2	0.56	0.56	0.50	0 52	0.56	0.55	0.50	0.51	0.56	0.55	0.50	0.51	0.56	0.54	0.50	0.50
	West facing window																
	School	0.51	0.59	0.41	0 54	0.51	0.58	0.41	0.53	0.51	0.58	0.41	0.53	0.51	0.57	0.41	0.52
	Office 1	0.51	0.59	0.41	0 54	0.51	0.58	0.41	0.53	0.51	0.58	0.41	0.53	0.51	0.57	0.41	0.52
	Office 2	0.56	0.59	0.50	0 54	0.56	0.58	0.50	0.53	0.56	0.58	0.50	0.53	0.56	0.57	0.50	0.52

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Scenario	Usage	Large room, small glazed area				Large room, intermediate glazed area, single opening				Large room, intermediate glazed area, multiple openings				Large room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Top-lit	Horizontal rooflight East-West																
	School	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37
	Office 1	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37
	Office 2	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37
	Horizontal rooflight North-south																
	School	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37
	Office 1	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37
	Office 2	0.43	0.55	0.36	0 51	0.34	0.46	0.30	0.43	0.34	0.46	0.30	0.43	0.23	0.41	0.20	0.37

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Table C.11 Small room daylight dependency factors (FD), as calculated by the current EN15193:2007 and prEN15193 revised. Usages: School – 08.30 to 16.00, Office 1 – 08.30 to 17.30, Office 2 – 06.00 to 18.00.

Scenario	Usage	Small room, small glazed area				Small room, intermediate glazed area				Small room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Side-lit, no obstructions	North facing window												
	School	0.66	0.64	0.52	0.57	0.36	0.57	0.29	0.49	0.36	0.55	0.29	0.48
	Office 1	0.66	0.64	0.52	0.57	0.36	0.57	0.29	0.49	0.36	0.55	0.29	0.48
	Office 2	0.68	0.64	0.57	0.57	0.45	0.57	0.42	0.49	0.45	0.55	0.42	0.48
	East facing window												
	School	0.66	0.60	0.52	0.54	0.36	0.53	0.29	0.47	0.36	0.51	0.29	0.46
	Office 1	0.66	0.60	0.52	0.54	0.36	0.53	0.29	0.47	0.36	0.51	0.29	0.46
	Office 2	0.68	0.60	0.57	0.54	0.45	0.53	0.42	0.47	0.45	0.51	0.42	0.46
	South facing window												
	School	0.66	0.56	0.52	0.52	0.36	0.49	0.29	0.45	0.36	0.48	0.29	0.44
	Office 1	0.66	0.56	0.52	0.52	0.36	0.49	0.29	0.45	0.36	0.48	0.29	0.44
	Office 2	0.68	0.56	0.57	0.52	0.45	0.49	0.42	0.45	0.45	0.48	0.42	0.44
	West facing window												
	School	0.66	0.60	0.52	0.54	0.36	0.53	0.29	0.47	0.36	0.51	0.29	0.46
	Office 1	0.66	0.60	0.52	0.54	0.36	0.53	0.29	0.47	0.36	0.51	0.29	0.46
	Office 2	0.68	0.60	0.57	0.54	0.45	0.53	0.42	0.47	0.45	0.51	0.42	0.46
Side-lit, linear obstruction	North facing window												
	School	0.66	0.70	0.52	0.63	0.51	0.63	0.41	0.56	0.51	0.58	0.41	0.50
	Office 1	0.66	0.70	0.52	0.63	0.51	0.63	0.41	0.56	0.51	0.58	0.41	0.50
	Office 2	0.68	0.70	0.57	0.63	0.56	0.63	0.50	0.56	0.56	0.58	0.50	0.50
	East facing window												
	School	0.66	0.68	0.52	0.62	0.51	0.59	0.41	0.54	0.51	0.54	0.41	0.47
	Office 1	0.66	0.68	0.52	0.62	0.51	0.59	0.41	0.54	0.51	0.54	0.41	0.47
	Office 2	0.68	0.68	0.57	0.62	0.56	0.59	0.50	0.54	0.56	0.54	0.50	0.47
	South facing window												
	School	0.66	0.65	0.52	0.61	0.51	0.56	0.41	0.52	0.51	0.50	0.41	0.45
	Office 1	0.66	0.65	0.52	0.61	0.51	0.56	0.41	0.52	0.51	0.50	0.41	0.45
	Office 2	0.68	0.65	0.57	0.61	0.56	0.56	0.50	0.52	0.56	0.50	0.50	0.45
	West facing window												
	School	0.66	0.68	0.52	0.62	0.51	0.59	0.41	0.54	0.51	0.54	0.41	0.47
	Office 1	0.66	0.68	0.52	0.62	0.51	0.59	0.41	0.54	0.51	0.54	0.41	0.47
	Office 2	0.68	0.68	0.57	0.62	0.56	0.59	0.50	0.54	0.56	0.54	0.50	0.47

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Scenario	Usage	Small room, small glazed area				Small room, intermediate glazed area				Small room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Side-lit, overhang	North facing window												
	School	0.66	0.72	0.52	0.64	0.66	0.64	0.52	0.57	0.51	0.61	0.41	0.54
	Office 1	0.66	0.72	0.52	0.64	0.66	0.64	0.52	0.57	0.51	0.61	0.41	0.54
	Office 2	0.68	0.72	0.57	0.64	0.68	0.64	0.57	0.57	0.56	0.61	0.50	0.54
	East facing window												
	School	0.66	0.69	0.52	0.63	0.66	0.60	0.52	0.54	0.51	0.57	0.41	0.52
	Office 1	0.66	0.69	0.52	0.63	0.66	0.60	0.52	0.54	0.51	0.57	0.41	0.52
	Office 2	0.68	0.69	0.57	0.63	0.68	0.60	0.57	0.54	0.56	0.57	0.50	0.52
	South facing window												
	School	0.66	0.67	0.52	0.62	0.66	0.56	0.52	0.52	0.51	0.54	0.41	0.50
	Office 1	0.66	0.67	0.52	0.62	0.66	0.56	0.52	0.52	0.51	0.54	0.41	0.50
	Office 2	0.68	0.67	0.57	0.62	0.68	0.56	0.57	0.52	0.56	0.54	0.50	0.50
	West facing window												
	School	0.66	0.69	0.52	0.63	0.66	0.60	0.52	0.54	0.51	0.57	0.41	0.52
	Office 1	0.66	0.69	0.52	0.63	0.66	0.60	0.52	0.54	0.51	0.57	0.41	0.52
	Office 2	0.68	0.69	0.57	0.63	0.68	0.60	0.57	0.54	0.56	0.57	0.50	0.52
Side-lit, courtyard	North facing window												
	School	0.66	0.73	0.52	0.65	0.66	0.67	0.52	0.60	0.51	0.62	0.41	0.55
	Office 1	0.66	0.73	0.52	0.65	0.66	0.67	0.52	0.60	0.51	0.62	0.41	0.55
	Office 2	0.68	0.73	0.57	0.65	0.68	0.67	0.57	0.60	0.56	0.62	0.50	0.55
	East facing window												
	School	0.66	0.70	0.52	0.64	0.66	0.64	0.52	0.60	0.51	0.58	0.41	0.53
	Office 1	0.66	0.70	0.52	0.64	0.66	0.64	0.52	0.60	0.51	0.58	0.41	0.53
	Office 2	0.68	0.70	0.57	0.64	0.68	0.64	0.57	0.60	0.56	0.58	0.50	0.53
	South facing window												
	School	0.66	0.67	0.52	0.63	0.66	0.62	0.52	0.59	0.51	0.55	0.41	0.51
	Office 1	0.66	0.67	0.52	0.63	0.66	0.62	0.52	0.59	0.51	0.55	0.41	0.51
	Office 2	0.68	0.67	0.57	0.63	0.68	0.62	0.57	0.59	0.56	0.55	0.50	0.51
	West facing window												
	School	0.66	0.70	0.52	0.64	0.66	0.64	0.52	0.60	0.51	0.58	0.41	0.53
	Office 1	0.66	0.70	0.52	0.64	0.66	0.64	0.52	0.60	0.51	0.58	0.41	0.53
	Office 2	0.68	0.70	0.57	0.64	0.68	0.64	0.57	0.60	0.56	0.58	0.50	0.53

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Scenario	Usage	Small room, small glazed area				Small room, intermediate glazed area				Small room, large glazed area			
		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux		Daylight dependency factor 500 Lux		Daylight dependency factor 300 Lux	
		EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)	EN15193 (Current)	prEN5193 (Revised)
Top-lit	Horizontal rooflight East-West												
	School	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51
	Office 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51
	Office 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51
	Horizontal rooflight North-south												
	School	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51
	Office 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51
	Office 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.55	0.36	0.51

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