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CSIRO

Addition of a Lighting Module to Accurate

Zhengen Ren and Dong Chen

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Report for Australian Government Department and Environment, Water Heritage and the Arts

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NOMENCLATURE

A	zone floor area = *L*W* (m^2)
AECZ	Annual energy consumed in zone (kWh)
ATMI	Acceptable threshold maintained illuminance (lm/m^2)
DF	dimming factor
EZW	Effective zone wattage (W)
GW	control gear wattage (W)
H	zone height (m)
IPD	illumination power density of the system (W/m^2)
L	Zone length (m)
LTU	Lumen Top Up (lm)
LW	lamp wattage (W)
MF	Maintenance factor
MLE	maintained luminous efficacy (lm/W)
MLP	Maintained lumens provided (lm)
NLPL	number of lamps per luminair
NLZ	number of luminairs in the zone
RAMI	Recommended Average Maintained Illuminance (lm/m^2)
RI	Room index
RSMF	room surface maintenance factor
SF	switching factor
Tol	Tolerance (=20%)
TUW	Top Up Wattage (W)
UF	utilization factor
W	zone width (m)

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Addition of a Lighting Module to AccuRate

Zhengen Ren and Dong Chen

CSIRO Sustainable Ecosystems

May 2009

EXECUTIVE SUMMARY

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a lighting module to the AccuRate software. The module calculates energy consumption and greenhouse gas emissions according to the lighting systems used in the house.

CSIRO was engaged by RBG to implement the lighting module in AccuRate. The project accomplished the following deliverables:

- A lighting page has been implemented in the AccuRate user interface, containing the input data fields required which include: zone length; room surface visible reflectances; luminaire type; number of luminaires; lamp type; lamp wattage; number of lamps in each luminaire; dimming control; and, switching control.
- The calculations of energy consumption in the lighting module are entirely based on the ANZHERS Electric Lighting Calculator, developed by Light Naturally in 2007 for the then DEWR [1].
- CO_2-e emissions are calculated from the electricity CO_2 intensities appropriate to the postcode.
- A new lighting report page has also been added to AccuRate's summary report, showing annual energy consumption, CO_2-e emissions, the average illumination power density of the house
- Star rating of the house lighting system will be further implemented when the star rating algorithms are available.
- A detailed lighting report is also available in AccuRate which describes the lighting systems used in each zone of the house.

1. BACKGROUND

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a lighting module to the AccuRate software. The module will calculate energy consumption and greenhouse gas emissions of the electric lighting system according to the lighting systems used in the house. CSIRO was engaged by RBG to implement the lighting module in AccuRate.

The project includes the following deliverables:

- A new page will be added to the AccuRate user interface, containing the input data fields required. Data entry will use the same style as the other pages.
- The user input data fields in the calculator are: zone name; zone type; zone length; zone width; zone height; room surface visible reflectances; luminaire type; number of luminaires; lamp type; lamp wattage; number of lamps in each luminaire; dimming control; and, switching control.
- Zone name, type and area are already specified in the current AccuRate user interface and so need not be re-entered by the user. They will automatically appear when the Lighting page is visible.
- The calculations of energy consumption will be entirely based on the ANZHERS Electric Lighting Calculator, developed by Light Naturally in 2007 for the then DEWR [1].
- CO_2-e emissions will be calculated from the electricity CO_2 intensities appropriate to the postcode.
- A new lighting report page will be added to AccuRate's reports, showing annual energy consumption and CO_2-e emissions.

This report details the implementation of the lighting module in AccuRate.

2. LIGHTING ENERGY CALCULATION METHODOLOGY

The implementation of the lighting module is entirely based on the ANZHERS Electric Lighting Calculator, developed by Light Naturally in 2007 for the then DEWR [1].

ANZHERS Electric Lighting Calculator [1] (referred here as Lighting Calculator in this report) adopted the lumen method to calculate how much light is required of and provided by electric lighting systems. This lighting calculation technique gives an average illuminance in an area based on information regarding how many lumens are supplied by the lamp, and how the luminaire and room surfaces act to transfer the lamp lumens to the plane of measurement. This calculation method is detailed in AS/NZS1680.1:2006 [2].

Lighting Calculator [1] reported that reducing the quantity of light (underlighting) in a space can achieve energy saving; however, this strategy could lead to buildings that appear energy efficient at specification, but fail to meet the visual needs of the occupants. It is likely that the actual energy consumption due to underlighting may increase as additional light sources are required by the occupants to supplement the inadequate lighting.

In order to compensate for the effect of underlighting in a zone, the quantity of light (measured by lumens) produced by specified lighting system in each zone will be compared with the lumens required to provide adequate light in that space. If the specified system fails to provide adequate lumens to a zone, the zone will be automatically ‘topped up’ to the required level under assumption of these extra ‘top up’ lumens provided at the lowest luminous efficacy possible (the worst case light source in terms of energy).

The calculation of energy consumption has been detailed in Lighting Calculator and its accompanying report by Light Naturally [1]. In this report, the formula and the parameters used in the lighting module implementation in AccuRate are listed. Table 1 shows the formula used for the calculation of the lighting energy.

It is noted that the current version of Lighting Calculator and thus the AccuRate Lighting module does not include natural lighting and certain lighting types such as LED lights. These issues will need to be addressed in future versions of the lighting module.

Table 1 Formula used for the calculation of the lighting energy (refer to Lighting Calculator [1])

Item Name and abbreviation	Formula	Comments
Room index (RI)	$RI = \frac{L \times W}{(H - 0.7) \times (L + W)}$ (1)	Where *L*, *W* and *H* are zone length, width and height, respectively. The RI value of Eq.(1) is rounded to the nearest value in the series: 0.75, 1, 1.25, 1.5, 2, 2.5, 3, 4, 5.
Acceptable threshold maintained illuminance (ATMI)	$ATMI = (1 - Tol) \times RAMI$ (2)	Where Tol is Tolerance (=20%) and RAMI is the Recommended Average Maintained Illuminance as listed in Table 2.
The threshold maintained lumens required (TMLR)	$TMLR = ATMI \times A$ (3)	Where *A* is zone floor area = $L \times W$.
Maintenance factor (MF)	$MF = 0.8 \times RSMF$ (4)	Where RSMF is room surface maintenance factor, which varies according to the flux distribution of the luminaires used as follow and detailed in Table 3: 0.95, for direct; 0.77, for indirect; 0.85, for direct/indirect.
Maintained lumens provided (MLP)	$MLP = MLE \times LW \times NLPL \times NLZ \times UF \times MF$ (5)	Where MLE is maintained luminous efficacy based on selected lamp and lamp wattage as shown in Table 4. LW, NLPL, NLZ are lamp wattage, number of lamps per luminair and number of luminairs in the zone respectively. UF is the utilization factor based on the room index, room surface reflectance and luminaire type as listed in Table 5. Room surface reflectance for different room surfaces is defined in Table 6.

Table 1 Formula used for the calculation of the lighting energy (Continued)

Item Name and abbreviation	Formula	Comments
Lumen Top Up (LTU)	If TMLR-MLP > 0, then $LTU = RAMI \times A - MLP$ (6)	LTU is required if the Maintained Lumens Provided is lower than the recommended level by more than the accepted tolerance level (20%). Lumen Top Up is the difference between the recommended maintained lumens required and the maintained lumens provided.
Top Up Wattage (TUW)	$TUW = LTU / 5.005$ (7)	When LTU is required, it will be achieved with the lowest efficacy source, i.e., incandescent GLS. The Top Up Wattage is calculated by dividing the Lumen Top Up required by the maintained luminous efficacy of the additional source (5.005). Top Up Wattage (TUW) must then be rounded up to the nearest whole lamp increment.
Effective zone wattage (EZW)	$EZW = (LW + GW) \times NLZ \times NLPL \times DF \times SF + TUW$ (8)	Where LW, NLZ and NLPL are described in Eq.(5). LW and GW are lamp wattage and control gear wattage as listed in Table 7. DF is dimming factor based on dim control type as shown in Table 8 and SF is the switching factor as shown in Table 9.
Annual energy consumed in zone (AECZ, kWh)	$AECZ = EZW \times ADHLU \times 365 / 1000$ (9)	Where ADHLU is the average daily hours of lump use as listed in Table 2 for different room types.
Illumination power density of the system (IPD, W/m^2)	$IPD = EZW / A$ (10)	The illumination power density of the system, IPD (W/m^2), is an energy metric for rating purposes.

Table 2 Recommended Average Maintained Illuminance (RAMI) and average daily hours of use (adapted from Lighting Calculator [1])

Zone Type	Recommended Avg Maintained Illuminance (lux)	Average Daily Hours of Use (hr)
Kitchen	160	4
Living/Dining	80	3
Bathroom	80	2
Bedroom	80	1.5
Entry/Corridor/Stairs	40	1.5
Other (daytime use)	40	0
Other (nighttime use)	80	1.5

Table 3 Room surface maintenance factor (adapted from Lighting Calculator [1])

Luminaire Type (flux distribution)	Description	RSMF
Direct	Recessed fittings e.g. downlights	0.95
Direct/Indirect	Surface Mounted or Suspended fittings e.g. Pendants, Bare Lamps, Opal Spheres, Oyster fittings, Battens	0.85
Indirect	Uplights	0.77

Table 4 Maintained luminous efficacy for selected lamp and lamp wattage (adapted from Lighting Calculator [1])

Lamp Type	Approximate Lamp Wattage (W)	Luminous Efficacy (lm/W)	LLMF	Maintained Luminous Efficacy (lm/W)
Incandescent GLS	25	10.8	0.79	8.5
	40	12.8	0.87	11.1
	60	14.3	0.93	13.3
	75	15.4	0.9	13.9
	100	16.5	0.9	14.9
	150	18.5	0.89	16.5
Low Voltage Tungsten Halogen + Transformer	20	15	0.85	12.8
	35	17	0.85	14.5
	50	19	0.85	16.2
	65	20	0.85	17.0

Table 4 Maintained luminous efficacy for selected lamp and lamp wattage (Continued)

Lamp Type	Approximate Lamp Wattage (W)	Luminous Efficacy (lm/W)	LLMF	Maintained Luminous Efficacy (lm/W)
Mains Voltage Halogen	75	18.7	0.96	18.0
	100	18.7	0.96	18.0
	150	18.7	0.96	18.0
Compact Fluorescent (Integrated Ballast)	5-8	40	0.8	32.0
	9-14	48	0.8	38.4
	15-24	55	0.8	44.0
	25-60	60	0.8	48.0
Compact Fluorescent + Electronic Ballast	5	50	0.8	40.0
	7	57	0.8	45.6
	9	67	0.8	53.6
	13-26	69	0.8	55.2
T8 Linear Fluorescent + Low Loss Magnetic Ballast	17-40	74	0.84	62.2
T8 Linear Fluorescent + Electronic Ballast	17-40	74	0.84	62.2
T5 Linear Fluorescent + Electronic Ballast	14	85.7	0.9	77.1
	21	90.5	0.9	81.5
	28	92.9	0.9	83.6
	35	94.3	0.9	84.9
T8 Circular Fluorescent + Low Loss Magnetic Ballast	17-40	74	0.84	62.2
	28-50	80	0.88	70.0
T8 Circular Fluorescent + Electronic Ballast	17-40	74	0.84	62.2
	28-50	80	0.88	70.0
T5 Circular Fluorescent + Electronic Ballast	14	85.7	0.9	77.1
	21	90.5	0.9	81.5
	28	92.9	0.9	83.6
	35	94.3	0.9	84.9

Table 5 Utilization factor based on room index, room surface reflectance and luminaire type (adapted from Lighting Calculator [1])

Room Index	Room Surface Reflectances	Luminaire Type		
0.75	light	0.55	0.45	0.3
	medium	0.5	0.4	
	dark	0.45	0.35	
1	light	0.61	0.52	0.36
	medium	0.55	0.46	
	dark	0.50	0.41	
1.25	light	0.62	0.54	0.37
	medium	0.57	0.48	
	dark	0.51	0.42	
1.5	light	0.64	0.56	0.39
	medium	0.58	0.50	
	dark	0.52	0.44	
2	light	0.67	0.59	0.42
	medium	0.61	0.53	
	dark	0.54	0.47	
2.5	light	0.70	0.63	0.45
	medium	0.63	0.56	
	dark	0.57	0.50	
3	light	0.73	0.66	0.48
	medium	0.66	0.59	
	dark	0.59	0.53	
4	light	0.79	0.73	0.54
	medium	0.71	0.66	
	dark	0.64	0.59	
5	light	0.8	0.75	0.55
	medium	0.73	0.68	
	dark	0.65	0.6	

* Data not found for medium and dark rooms (suggest that they are not recommended for use in indirect lighting schemes)

Table 6 Description of room surface reflectance (adapted from Lighting Calculator [1])

Room Surface Visible Reflectances (%ceiling/walls/floors)	Description
Light: 70/50/20	this would describe a room with a white ceiling and white or li walls, and light neutral carpet or light timber floors
Medium: 60/40/15	
Dark: 50/30/10	this would describe a room with dark or common brick walls, a timber, ‘low maintenance’ carpet or tile floors

Table 7 Control gear wattage for different lamp types (adapted from Lighting Calculator [1])

Lamp Type	**Gear Wattage (W)**
Incandescent GLS	0
Incandescent Candelabra	0
Low Voltage Tungsten Halogen + Transformer	3
Mains Voltage Halogen	0
Compact Fluorescent (Integrated Ballast)	0
Compact Fluorescent + Electronic Ballast	3
T8 Linear Fluorescent + Low Loss Magnetic Ballast	5
T8 Linear Fluorescent + Electronic Ballast	2
T8 Circular Fluorescent + Low Loss Magnetic Ballast	5
T8 Circular Fluorescent + Electronic Ballast Ballast	2
T5 Linear Fluorescent + Electronic Ballast	4
T5 Circular Fluorescent + Electronic Ballast	4

Table 8 Dimming factor for different dim control types (adapted from Lighting Calculator [1])

Zone Dimming Control	**Factor**
	1
no dimming	1
manual dimming	0.95

Table 9 Switching factor for different switching mechanisms (adapted from Lighting Calculator [1])

Zone Switching Control	**Factor**
	1
manual switching	1
motion sensor switching	0.55
automatic timed switching	0.85

3. LIGHTING CO_2 EMISSION CALCULATION METHODOLOGY

Lighting annual carbon emission (kg CO_2-e) is calculated by Eq. (11)

$$CE = 0.0036\left(\sum AECZ\right)\times CEE_f \qquad (11)$$

Where:

∑AECZ	Annual lighting energy consumed in the house (kWh)
CE	Carbon emission (kg/annual)
CEE_f	Carbon emission factor of electricity (kg CO_2-e/GJ) as in Table 10

Table 10 Carbon emission factor of electricity (kg CO_2-e/GJ)

State	**Carbon emission factor of electricity**
ACT	295
NSW	295
VIC	364
QLD	289
SA	272
WA	271
TAS	37
NT	221

Source: National Greenhouse Accounts (NGA) Factors (2008)

4. IMPLEMENTATION OF LIGHTING MODULE IN ACCURATE

Figure 1 shows the overview of the process of inputting data for AccuRate to calculate the annual lighting energy consumption. Green indicates existing AccuRate inputs that will be used; input types and options highlighted in orange are the proposed new additions required to complete the evaluation.

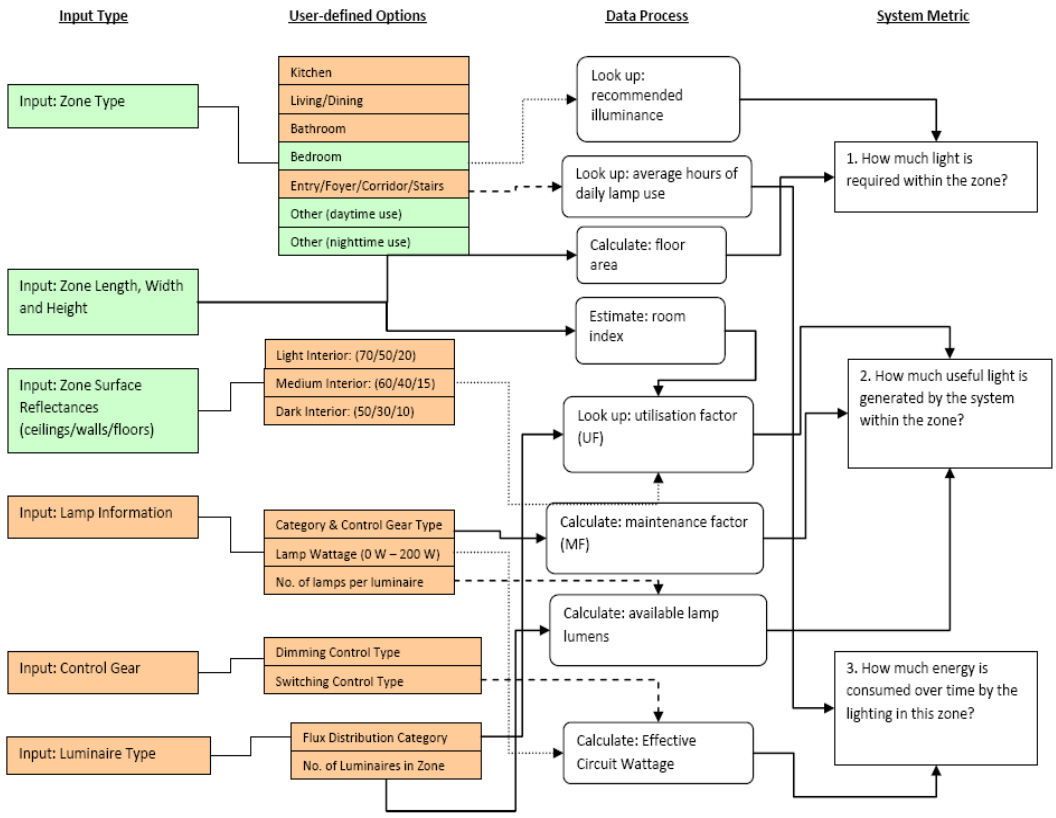


Figure 1. Overview of lighting evaluation method (adapted from Fig. 1. of [1])

Using the same style as the other AccuRate input pages, a lighting page has been added to the AccuRate user interface as shown in Figure 2, which contains the input data fields required. The user input data fields are: zone length; room surface visible reflectances; luminaire type; number of luminaires; lamp type; lamp wattage; number of lamps in each luminaire; dimming control; and switching control.

In the current AccuRate user interface, zone name, type and area are already specified. The zone type is classified as: living, bedroom, living/kitchen, other (daytime usage), other (night-time usage), garage, roof space and subfloor. In the lighting module, the zone type is specified as: kitchen, living/dining, bathroom, bedroom, entry/corridor/stairs, other (daytime usage), other (night-time usage). So a zone specified as living/kitchen needs to be split into a kitchen and a living area in the lighting module. Bathroom and entry/corridor/stairs also need to be separated from the Other (daytime usage) and other (night-time usage) types as shown in Fig.2.

As shown in Fig. 2, the Living/kitchen zone has been split into a kitchen and a living area with the area of living space specified as a percentage of the Living/kitchen zone

area. For each zone, the lighting information is entered at the bottom left corner of the lighting page and the calculation of the lighting energy consumption is shown at the bottom right corner under the “Calculation” button. As shown in Fig. 3, the “Energy Consumed” button displays the total house annual lighting energy consumption, the annual house CO_2-e emissions due to lighting and the average illumination power density of the house.

Figure 4 shows the summary report for the results of the lighting energy consumption. Star rating of the house lighting system will be further implemented when the star rating algorithms are available. Details of the house lighting systems are also described immediately after the house thermal modeling detail report as shown in Fig. 5.

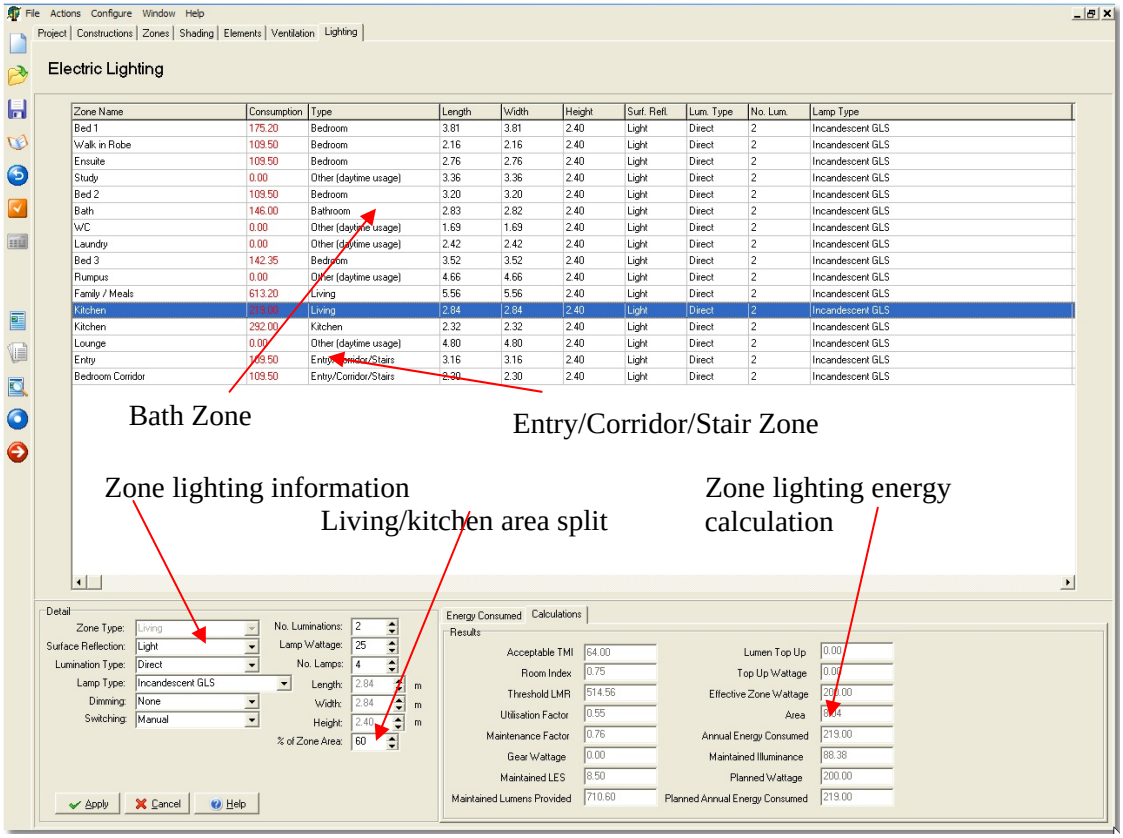


Figure 2. Lighting page implemented in AccuRate

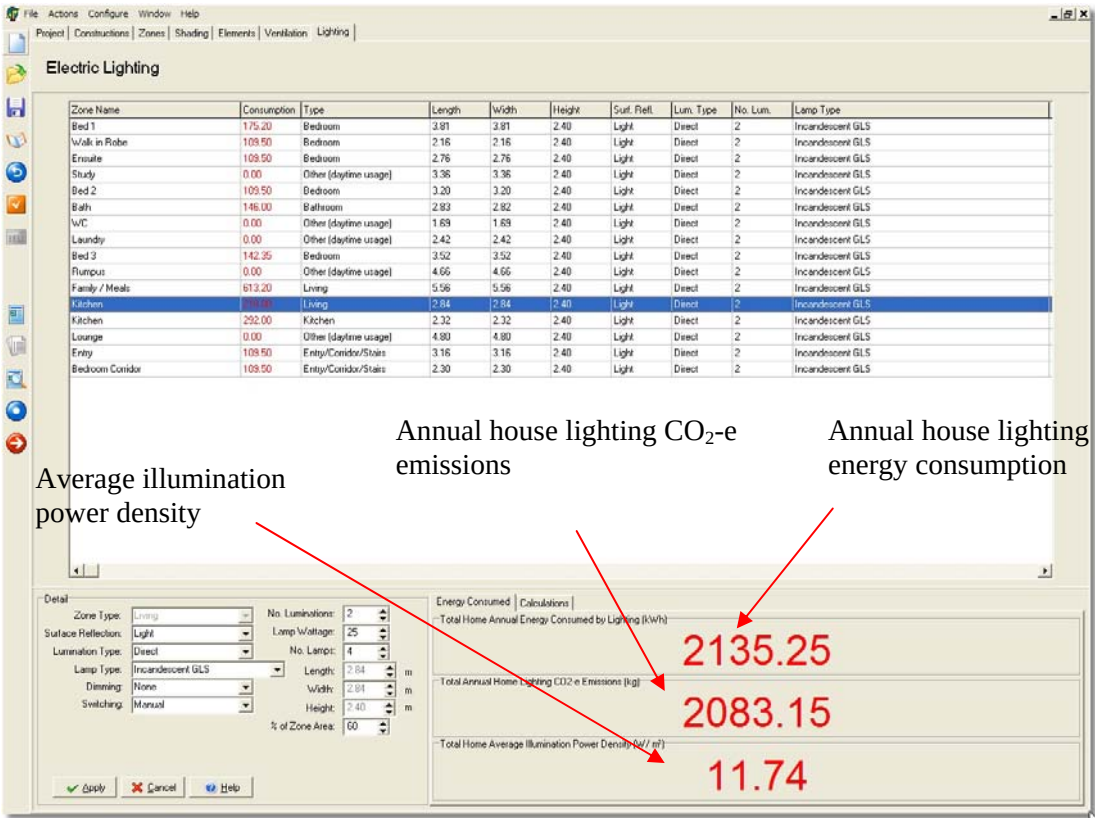
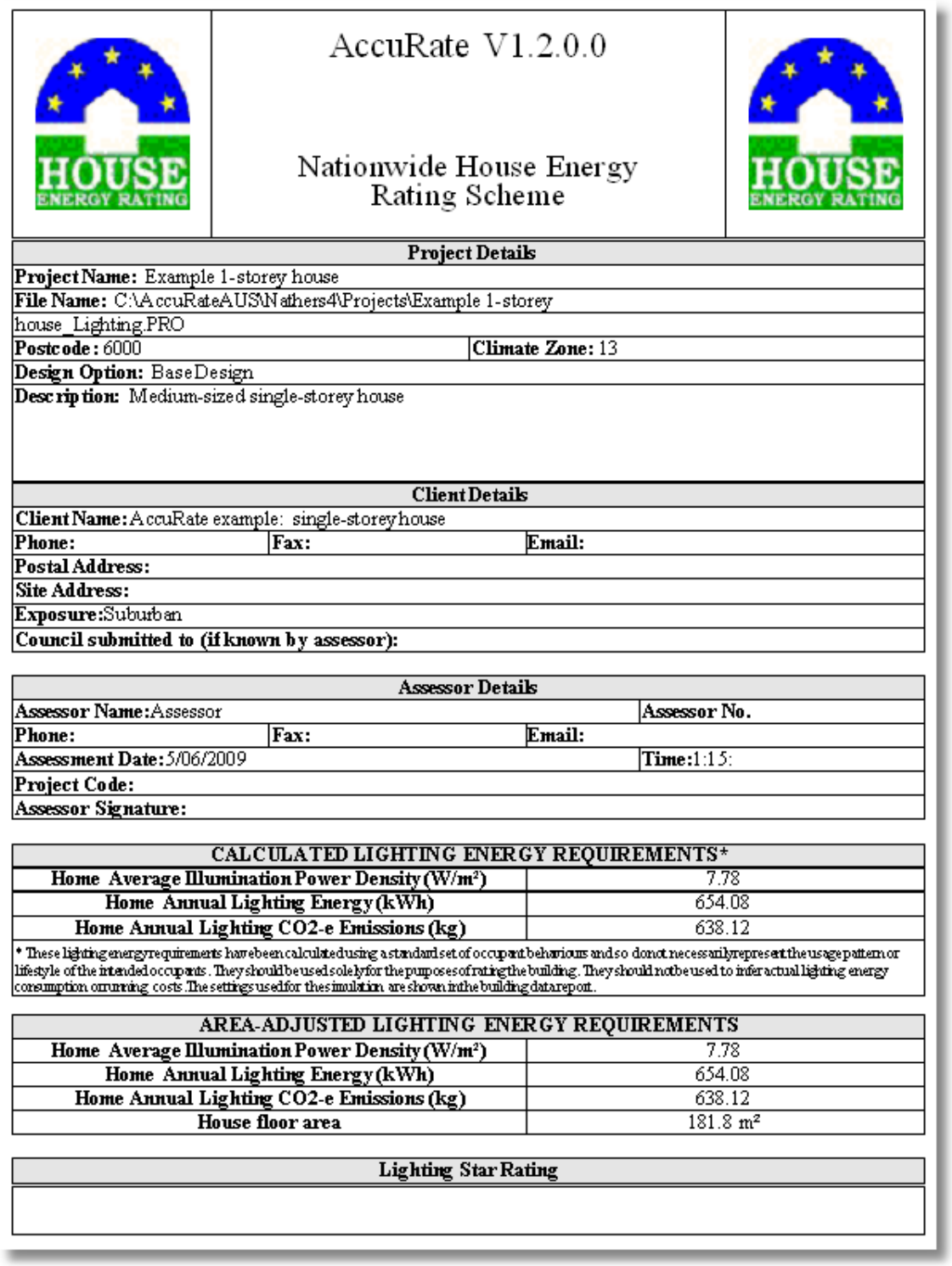


Figure 3. Lighting page shows total home annual lighting energy consumption



AccuRate V1.2.0.0

Nationwide House Energy Rating Scheme

Project Details	
Project Name: Example 1-storey house	
File Name: C:\AccuRateAUS\Nathers4\Projects\Example 1-storey house_Lighting.PRO	
Postcode: 6000	**Climate Zone:** 13
Design Option: Base Design	
Description: Medium-sized single-storey house	

Client Details		
Client Name: AccuRate example: single-storey house		
Phone:	**Fax:**	**Email:**
Postal Address:		
Site Address:		
Exposure: Suburban		
Council submitted to (if known by assessor):		

Assessor Details			
Assessor Name: Assessor			**Assessor No.**
Phone:	**Fax:**	**Email:**	
Assessment Date: 5/06/2009			**Time:** 1:15:
Project Code:			
Assessor Signature:			

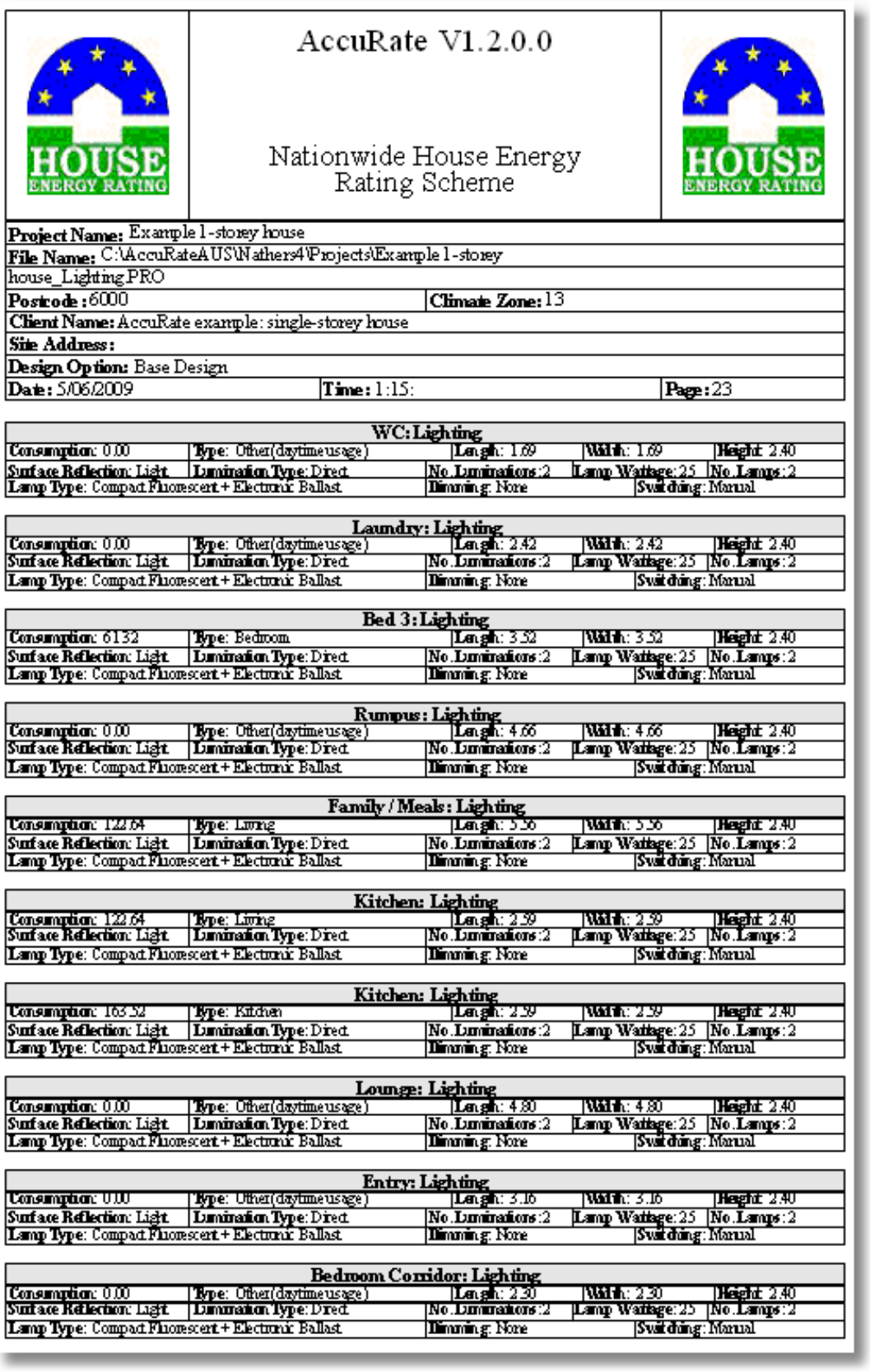
CALCULATED LIGHTING ENERGY REQUIREMENTS*	
Home Average Illumination Power Density (W/m²)	7.78
Home Annual Lighting Energy (kWh)	654.08
Home Annual Lighting CO2-e Emissions (kg)	638.12

* These lighting energy requirements have been calculated using a standard set of occupant behaviours and so do not necessarily represent the usage pattern or lifestyle of the intended occupants. They should be used solely for the purposes of rating the building. They should not be used to infer actual lighting energy consumption or running costs. The settings used for this simulation are shown in the building data report.

AREA-ADJUSTED LIGHTING ENERGY REQUIREMENTS	
Home Average Illumination Power Density (W/m²)	7.78
Home Annual Lighting Energy (kWh)	654.08
Home Annual Lighting CO2-e Emissions (kg)	638.12
House floor area	181.8 m²

Lighting Star Rating

Figure 4. Lighting summary report



AccuRate V1.2.0.0

Nationwide House Energy Rating Scheme

Project Name: Example 1-storey house		
File Name: C:\AccuRateAUS\Nathers4\Projects\Example 1-storey house_Lighting.PRO		
Postcode : 6000	**Climate Zone:** 13	
Client Name: AccuRate example: single-storey house		
Site Address:		
Design Option: Base Design		
Date: 5/06/2009	**Time:** 1:15:	**Page:** 23

WC: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 1.69	**Width:** 1.69	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Laundry: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 2.42	**Width:** 2.42	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Bed 3: Lighting				
Consumption: 61.32	**Type:** Bedroom	**Length:** 3.52	**Width:** 3.52	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Rumpus: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 4.66	**Width:** 4.66	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Family / Meals: Lighting				
Consumption: 122.64	**Type:** Living	**Length:** 5.56	**Width:** 5.56	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Kitchen: Lighting				
Consumption: 122.64	**Type:** Living	**Length:** 2.59	**Width:** 2.59	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Kitchen: Lighting				
Consumption: 163.52	**Type:** Kitchen	**Length:** 2.59	**Width:** 2.59	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Lounge: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 4.80	**Width:** 4.80	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Entry: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 3.16	**Width:** 3.16	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Bedroom Corridor: Lighting				
Consumption: 0.00	**Type:** Other(daytime usage)	**Length:** 2.30	**Width:** 2.30	**Height:** 2.40
Surface Reflection: Light	**Lumination Type:** Direct	**No.Luminations:** 2	**Lamp Wattage:** 25	**No.Lamps:** 2
Lamp Type: Compact Fluorescent + Electronic Ballast		**Dimming:** None	**Switching:** Manual	

Figure 5. Detailed report for house lighting systems

5. CONCLUSIONS

A lighting module has been implemented in AccuRate based on the ANZHERS Electric Lighting Calculator, developed by Light Naturally in 2007 [1]. This project accomplished the following deliverables:

- A lighting page has been implemented in the AccuRate user interface, containing the input data fields required which include: zone length; room surface visible reflectances; luminaire type; number of luminaires; lamp type; lamp wattage; number of lamps in each luminaire; dimming control; and switching control.
- The calculations of energy consumption in this lighting page are entirely based on the ANZHERS Electric Lighting Calculator, developed by Light Naturally in 2007 for the then DEWR [1].
- CO_2-e emissions are calculated from the electricity CO_2 intensities appropriate to the postcode.
- A new lighting report page has also been added to AccuRate's summary report, showing annual energy consumption, CO_2-e emissions, the average illumination power density. Star rating of the house lighting system will be further implemented when the star rating algorithms are available.
- A detailed lighting report is also available in AccuRate which describing the lighting systems used in each zone of the house.

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1. Isoardi G. and Coyne S. (2007) Light Naturally – ANZHERS electric lighting system module: energy calculation report, submitted to AGO (Australia Green Office).
2. AS/NZS 1680.1:2006 – Interior and workplace lighting – General principles and recommendations.

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