

# Addition of a Lighting Module to Accurate

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## NOMENCLATURE

Α	zone floor area = $L^*W(m^2)$
AECZ	Annual energy consumed in zone (kWh)
ATMI	Acceptable threshold maintained illuminance (Im/m <sup>2</sup> )
DF	dimming factor
EZW	Effective zone wattage (W)
GW	control gear wattage (W)
Н	zone height (m)
IPD	illumination power density of the system (W/m <sup>2</sup> )
L	Zone length (m)
LTU	Lumen Top Up (Im)
LW	lamp wattage (W)
MF	Maintenance factor
MLE	maintained luminous efficacy (Im/W)
MLP	Maintained lumens provided (Im)
NLPL	number of lamps per luminair
NLZ	number of luminairs in the zone
RAMI	Recommended Average Maintained Illuminance (Im/m <sup>2</sup> )
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

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#### CSIRO Sustainable Ecosystems

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### 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<sub>2</sub>-e emissions are calculated from the electricity CO<sub>2</sub> intensities appropriate to the postcode.
- A new lighting report page has also been added to AccuRate's summary report, showing annual energy consumption, CO<sub>2</sub>-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<sub>2</sub>-e emissions will be calculated from the electricity CO<sub>2</sub> intensities appropriate to the postcode.
- A new lighting report page will be added to AccuRate's reports, showing annual energy consumption and CO<sub>2</sub>-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.

Item Name and abbreviation	Formula	Comments
Room index (RI)	$RI = \frac{L \times W}{(H - 0.7) \times (L + W)} \tag{1}$	Where <i>L</i> , <i>W</i> and <i>H</i> 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)	$ATMI = (1 - Tol) \times RAMI \tag{2}$	Where Tol is Tolerance (=20%) and RAMI is the Recommended Average Maintained Illuminance as listed in Table 2.
The threshold maintained lumens required (TMLR)	$TMLR = ATMI \times A \tag{3}$	Where <i>A</i> is zone floor area = $L \times W$ .
Maintenance factor (MF)	$MF = 0.8 \times RSMF \tag{4}$	<ul> <li>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;</li> <li>0.77, for indirect;</li> <li>0.85, for direct/indirect.</li> </ul>
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 (refer to Lighting Calculator [1])

Item Name and abbreviation	Formula	Comments
Lumen Top Up (LTU)	If TMLR-MLP $> 0$ , then	LTU is required if the Maintained Lumens Provided
	$LTU = RAMI \times A - MLP \tag{6}$	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)	$TUW = LTU / 5.005 \tag{7}$	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 wettere (EZW)	$EZW = (IW + CW) \times NIZ \times NIDI \times DE \times SE + TUW$	Where I.W. NI Z and NI DL are described in Eq. (5)
Effective zone wattage (EZW)	$EZW = (LW + GW) \times NLZ \times NLPL \times DF \times SF + IUW$	I W and GW are lamp wattage and control gear
	(8)	wattage as listed in Table 7. DE is dimming factor
		based on dim control type as shown in Table 8 and
		SF is the switching factor as shown in Table 9
		ST is the switching factor as shown in Factory.
Annual energy consumed in	$AECZ = EZW \times ADHLU \times 365/1000 $ (9)	Where ADHLU is the average daily hours of lump
zone (AECZ, kWh)		use as listed in Table 2 for different room types.
Illumination power density of	$IPD = EZW / A \tag{10}$	The illumination power density of the system, IPD
the system (IPD, $W/m^2$ )		$(W/m^2)$ , is an energy metric for rating purposes.

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

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
	Surface Mounted or Suspended fittings e.g. Pendants, Bare Lamps, Opal	
Direct/Indirect	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

Lomp Type	Approximate Lamp Wattage	Luminous Efficacy	LLMF	Maintained Luminous
Maina Voltaga Halagan	75	(111/ VV)	0.04	
	100	10.7	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 4 Maintained luminous efficacy for selected lamp and lamp wattage (Continued)

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		

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

\* 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 Calc	ulator [1])
---	-----------------------------	-------------

Room Surface Visible Reflectances	Description
(%ceiling/walls/floors)	
Light: 70/50/20	this would describe a room with a white ceiling and white or light
	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

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

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<sub>2</sub> EMISSION CALCULATION METHODOLOGY

Lighting annual carbon emission (kg CO<sub>2</sub>-e) is calculated by Eq. (11)

$$CE = 0.0036 \left(\sum AECZ\right) \times CEE_f \tag{11}$$

Where:

ΣAFCZ	Annual lighting energy consumed in the house (kWh)
CE	Carbon emission (kg/annual)
CEE <sub>f</sub>	Carbon emission factor of electricity (kg CO <sub>2</sub> -e/GJ) as in Table 10

Table 10 Carbon emission factor of electricity (kg CO<sub>2</sub>-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 specified zone type is 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.

#### IMPLEMENTATION OF LIGHTING MODULE IN ACCURATE

ecure Lighting									
Zone Name	Consumpti	on Type	Length	Width	Height	Surf. Refl.	Lum. Type	No. Lum.	Lamp Type
Bed 1	175.20	Bedroom	3.81	3.81	2.40	Light	Direct	2	Incandescent GLS
Walk in Robe	109.50	Bedroom	2.16	2.16	2.40	Light	Direct	2	Incandescent GLS
Ensuite	109.50	Bedroom	2.76	2.76	2.40	Light	Direct	2	Incandescent GLS
Study	0.00	Other (daytime usage)	3.36	3.36	2.40	Light	Direct	2	Incandescent GLS
Bed 2	109.50	Bedroom	3.20	3.20	2.40	Light	Direct	2	Incandescent GLS
Bath	146.00	Bathroom 🚽	2.83	2.82	2.40	Light	Direct	2	Incandescent GLS
WC	0.00	Other (daytine usage)	1.69	1.69	2.40	Light	Direct	2	Incandescent GLS
Laundry	0.00	Other (daytime usage)	2.42	2.42	2.40	Light	Direct	2	Incandescent GLS
Bed 3	142.35	Bedroom	3.52	3.52	2.40	Light	Direct	2	Incandescent GLS
Rumpus	0.00	Other (daytime usage)	4.66	4.66	2.40	Light	Direct	2	Incandescent GLS
Family / Meals	613.20	Living	5.56	5.56	2.40	Light	Direct	2	Incandescent GLS
Kitchen	219.00	Living	2.84	2.84	2.40	Light	Direct	2	Incandescent GLS
Kitchen	292.00	Kitchen	2.32	2.32	2.40	Light	Direct	2	Incandescent GLS
Lounge	0.00	Other (daytime usage)	4.80	4.80	2.40	Light	Direct	2	Incandescent GLS
Entry	109.50	Entry, preidor/Stairs	3.16	3.16	2.40	Light	Direct	2	Incandescent GLS
Beardoin Comaoi	103.30	Entry/Conicci/Stars	2.00	2.30	2.40	Light	Dilect	4	Incandescent dL3
Bath	Zone			En	try/C	orrido	r/Stai	r Zor	ie
Bath Zone lig	Zone ghting in	formation Living/k	itch⁄eı	En n area	try/Co a split	orrido	r/Stai Zor cal	r Zor ne lig culati	e hting energy on
Zone lig	Zone ghting in	formation Living/k	itcher	En n area	try/Co split	orrido	r/Stai Zor cal	r Zor ne lig culati	te hting energy on
Bath Zone lig	Zone ghting in	formation Living/k	itcher Energy C Results	En n area	try/Co a split	orrido	r/Stai Zo: cal	r Zor ne lig culati	the shting energy son
Bath Z Zone lig Zone type: Cone Type: Light maximum Type: Direct	Zone ghting in	formation Living/k	itcher Energy C Results	En n area	try/Co split culations	orrido	r/Stai Zor cal	r Zor ne lig culati	hting energy
Bath Z Zone lig Zone lype Cone Type: Light Cone Type: Light Light Light Light Cone type: Light Light Light Cone lig	Zone ghting in	formation Living/k	itcher Energy C Results	En n area onsumed Cal Acceptat Room	try/Co split culations le TMI 64.00 Index 0.75	orrido	r/Stai Zor cal	r Zor ne lig culati	the second secon
Bath Z Zone lig Zone Jype: Umg Zone Type: Umg Indiana Type: Direct Lang Type: Tricandecert Direct Direct Rome	Zone ghting in	formation Living/k	itcher Energy C Results	En n area onsumed Cal Acceptat Room Threshol	try/Co a split culations late TMI E4.0C lindex 0.75 dLMB 514.55	orrido	r/Stai Zo: cal	r Zor ne lig culati	hting energy on
Bath Z Zone lig Zone Type: Cone Type: Lamp Type: Incandescent Diming: None Swetching Manyud	Zone ghting in	formation Living/k	itcher Energy C Results	En n area onsumed Cal Acceptat Room Threshoul	try/Co split culations we TMI 64.000 JUMR 514.5 sector 0.55	orrido	r/Stai Zoi cal	r Zor ne lig culati	hting energy
Bath Z Zone Ise Core	Zone ghting in	formation Living/k	itcher Energy C Results	En n area onsumed Cal Acceptat Room Thresholl Utilisation	try/Co split culations le TMI 64.00 LIMB 514.5 LIMB 514.5 Sactor 0.75 Sactor 0.75		r/Stai Zou cal Effectiv	r Zor ne lig culati	hting energy on
Bath Z Zone Iig Zone Iype: Umg Zone Type: Umg Direct Lang Type: Treandecent Direct Switching: Manual	Zone ghting in	formation Living/k	Energy C Results	En onsumed Cal Acceptat Room Threshole Utiliteance I	try/Co a split culations de TMI 64.00 lindex 0.75 dLMR 514.54 dLMR 514.54 cutor 0.55 cator 0.76	orrido	r/Stai Zoi cal Effectiv	r Zor ne lig culati	hting energy

Figure 2. Lighting page implemented in AccuRate

le u	Le.	1.	1	L. e.u.	Terror.	In case	1	Line and	
Zone Name	Lonsumph	on Type	Length	Width	Height	Suit. Hell	Lum Type	No. Lum.	Lamp Type
Deu I Walk in Rohe	1/9.20	Dedroom	2.01	3.01	2.40	Light	Direct	2	Incendescent GLS
Fanda	109.50	Perhanan	2.16	2.10	2.40	Light	Direct	2	Incardescent GLS
Shada	0.00	Other (dautime unage)	3.36	3.36	2 40	Light	Direct	2	Incondescent GLS
Red 2	109.50	Redroom	3.20	3.20	2.40	Links	Direct	2	Incardeneer GLS
Balh	146.00	Bathroom	2.83	2.82	2.40	Linte	Drect	2	Incardecent GLS
wr	0.00	Other (daytime usage)	1.69	1.69	2.40	Linkt	Direct	2	Incondescent GLS
Laundry	0.00	Other (daytime usage)	2.42	2.42	2.40	Liebt	Direct	2	Incandescent GLS
Bed 3	142.35	Bedroom	3.52	3.52	2.40	Light	Drect	2	Incandescent GLS
Bumpus	0.00	Other (daytime usage)	4.66	4.66	2.40	Light	Direct	2	Incandescent GLS
Family / Meals	613.20	Living	5.56	5.56	2.40	Light	Drect	2	Incandescent GLS
THE REAL PROPERTY AND ADDRESS OF	216.00	Living	2.84	2.84	2.40	Light	Direct	2	Incondescent GLS
Nitchen		and the second s	2.22	2.32	2.40	Light	Direct	2	Incandescent GLS
Kitchen	292.00	Kitchen	2.36	and the second second					
Kitchen Lounge	292.00 0.00	Kitchen Other (daytme usage)	4.80	4.80	2.40	Light	Direct	2	Incandescent GLS
Kitchen Lounge Entry	292.00 0.00 109.50	Kitchen Other (daytime usage) Entry/Corridor/Stairs	4.80	4.80	2.40	Light	Direct Direct	2	Incandescent GLS Incandescent GLS
Noteen Kitchen Lounge Entry Bedroom Conidor	292.00 0.00 108.50 109.50	Kitchen Other (daytime usage) Entry/Conidor/Stains Entry/Conidor/Stains	4.80 3.16 2.30	4.80 3.16 2.30	240 240 240 240	Light Light Light	Direct Direct Direct	e e	Incardescent GLS Inconductoret GLS Incardescent GLS Annual house lig
Kachen Loorge Erhy Bedoom Conidor	232.00 0.00 109.50 108.50	Kichen Other (dynne usage) Entry/Conidor/Stain Entry/Conidor/Stain Entry/Conidor/Stain Entry/Conidor/Stain	4.80 3.16 2.30	4.80 315 2.30 1 hou ons	240 240 240	Light Light Light	Direct Direct Direct	e	Incardencert GLS Incondencert GLS Incardencert GLS Annual house lig energy consumpt
kichen Lounge Erny Bedoom Conidor	20200 10850 10850	Kichen Offre (dayline usage) Enty/Corido/Stais Enty/Corido/Stais Enty/Corido/Stais	4.80 3.16 2.30	4.80 3.16 2.30	240 240 240 240	Light Light Light	Direct Direct Direct CO <sub>2</sub> -	e	Incardecere GLS Incondecere GLS Incardecere GLS Annual house lig energy consumpt
Kachen Lunge Erky Bedoon Conidor	222.00 103.50 103.50	Kichen Othe (dayline usage) Enty/Corido/Stain Enty/Corido/Stain Enty/Corido/Stain Corido/Stain	480 316 230	4.80 3.16 2.30	240 240 240 240	Light Light Light	Direct Direct Direct	2 2 2 2	Incardeneer GLS Incardeneer GLS Annual house lig energy consumpt
Verage illun ower density	20200 0.00 10850 10550	Kichen Ofher (dayline usage) Entry/Coridor/Stain Entry/Coridor/Stain Ref	480 316 230	480 3.16 2.30	240 240 240 240	Light Light Light	Direct Direct Direct	e	Incardeneer GLS Incordeneer GLS Annual house lig energy consumpt
Verage illun	22200 000 10850 10850	Kichen Often (dayline usage) Entry/Coridox/Stait Entry/Coridox/Stait C	480 316 230	480 3.16 2.30	240 240 240 240	Light Light Light Light	Direct Direct Direct Direct	e e	Incardecert 613 Incondecert 615 Incardecert 615 Annual house lig energy consumpt
Verage illun ower density	222.00 0.00 103.50 103.50	Kichen Offre (dayline usage) Entry/Corido/Stain Entry/Corido/Stain Entry/Corido/Stain	480 316 230	480 316 230 1 hou ons	240 240 240 240 se lig	Light Light Light	Direct Direct Direct Direct	e	Incardeneer 613 Incardeneer 615 Incardeneer 615 Annual house lig energy consumpt
Verage illum verage illum verage status verage illum verage illum	222.00 0.00 108.50 108.50	Kichen Ofher (dayline usage) Entry/Coridor/Stain Entry/Coridor/Stain Entry/Coridor/Stain	4.80 3.16 2.30 Annua missio	and a second sec	2.40 2.40 2.40 se lig	Light Light Light Light Light Light	Direct Direct Direct Direct	e e	Incardeneer GLS Incordeneer GLS Incardeneer GLS Annual house lig energy consumpt
Victoria Kichen Lange Erny Bedrom Conidar Verage illum Dower density	22200 000 10850 10850	Kichen Offen (daylme usage) Entry/Conidox/Staits Entry/Conidox/Staits A C: Lunieutions: 2	4.80 3.16 2.30 Annua missio	4.80 3.16 2.30 1 hou ons onsumed Column	2.40 2.40 2.40 2.40 se lig	Light Light Light Light Light Light	CO <sub>2</sub> -	2 2 2 2 2 2	Inconducer 613 Inconducer 615 Inconducer 615 Annual house lig energy consumpt
Verage illum bedoon Condur Fray Bedoon Condur Verage illum ower density	222.00 0.00 109.50 109.50 109.50	Kichen Offre (daylme usage) Entry/Corido/Stain Entry/Corido/Stain Entry/Corido/Stain A C C unido/Stain Entry/Corido/Stain A C C	4.80 3.16 2.30 Annua missio	aso 316 230 1 hou ons onsumed Cal onsumed Cal	2.40 2.40 2.40 2.40 see lig	Light Light Light Light Light hting	CO <sub>2</sub> -	e 35.	Incardecert 613 Incardecert 615 Incardecert 615 Annual house lig energy consumpt
Voterage illum Verage illum Dever density verage rates and the second verage illum Dever density date Patheton. Laft Lang Type, Torreton Lang Type, Torreton Torreton	222.00 0.00 108.50 108.50 nination 7	Kichen Offre (dayline usage) Entry/Corido/Stais Entry/Corido/Stais Entry/Corido/Stais United Stais A C C United Stais C C C C C C C C C C C C C C C C C C C	4.80 3.16 2.30	4.80 3.16 2.30 1 hou onsumed Cal mee Annual En-	2.40 2.40 2.40 se lig southing   egg Consumed	Light Light Light Light hting	CO <sub>2</sub> -	e 35.	Incardecere 613 Incondecere 615 Incardecere 615 Annual house lig energy consumpt
tadoo Kachen Lounge Erry Bedoom Conidor Bedoom Conidor Uverage illum ower density also Reflection. Lybi Lumination Type. Deed Diaring None Statchen Manuel	222.00 0.00 108.50 108.50	Kichen Othe (dayline usage) Entry/Corido/Stain Entry/Corido/Stain Entry/Corido/Stain Entry/Corido/Stain Corido/Stain Entry/Cori	4.80 3.16 2.30 Annua missio	and the second s	2.40 2.40 2.40 se lig se lig exact on the second se	Light Light Light Light Light Light Light Light Light Light Light Light	CO <sub>2</sub> -	e 35.	Incardencer 613 Incardencer 615 Incardencer 615 Annual house lig energy consumpt

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

	AccuRate V1	2.0.0
HOUSE ENERGY RATING	Nationwide Hous Rating Sche	e Energy eme HOUSE ENERGY RATING
	Project Detai	k
Project Name: Example	1-storev house	
File Name: C:\AccuRat	eAUS\Nathers4\Projects\Example 1-sto	orev
house Lighting.PRO		
Postcode: 6000	Clima	te Zone: 13
Design Option: BaseD(	esign	
Description: Medium-s	ized single-storey house	
	('lient Detail	s
Client Name: A cmiRate	evernnle: single-storey house	<u> </u>
Phone:	Fax:	Fmail
Postal Address	Tan.	слан.
Site Address		
Exposure:Suburban		
Council cubmitted to G	flemour by according	
Connen ammitten in (i	I KROWR Dy assessory:	
	Assessor Detai	ik
Assessor Name: Assesso	TERRISOT FETA	Assessor No.
Phone:	Fax:	Email:
Assessment Date: 5/06/2	2009	Time:1:15:
Project Code:		120011.13
Assessor Signature		
issessor ognature.		
	CALCULATED LIGHTING ENER	GY REOUIREMENTS*
Home Average Illu	mination Power Density (W/m <sup>2</sup> )	7.78
Ноте Анни	al Lighting Energy (kWh)	654.08
Home Annual L	ighting CO2-e Emissions (kg)	638.12
<ul> <li>These lighting energy requirement</li> </ul>	ts have been calculated using a standard set of occupan	t behaviours and so donot necessarily represent the usage pattern or
lifestyle of the intended occupants . consimption or unning costs . The	They should be used solely for the purposes of rating the settings used for the simulation are shown in the build in	e building. They should not be used to inferactual lighting energy g datareport.
A	REA-ADJUSTED LIGHTING ENE	RGY REQUIREMENTS
Home Average Illu	mination Power Density (W/m²)	7.78
Home Annu	al Lighting Energy(kWh)	654.08
Home Annual L	ighting CO2-e Emissions (kg)	638.12
Н	ouse floor area	181.8 m <sup>2</sup>
	Lighting Star Ra	ting
	<u> </u>	<u> </u>

Figure 4. Lighting summary report

HOUSE	AccuRate Nationwide F	V1.2.0.0	sy HOUS	Ē
ENERGY RATING	Kating	Scheme	ENERGY RAT	ING
Project Name: Exampl	e l-storey house			
File Name: C:\AccuRat	eAUS\Nathers4\Projects\Examp	le 1-storey		
Postcode: 6000		Climate Zone: 13	}	
Client Name: AccuRate	e example: single-storey house			
Sile Address: Design Ontion: Base D	ocian			
Date: 5/06/2009	Time: 1:15:		Page:23	
	WC.I			
Consumption: 0.00	WC:L Type: Ofher(daytimeusage)	Lengh: 1.69	Walth: 1.69 Height 2.4	0
Sunface Reflection: Light	Lumination Type: Direct	No Luminations :2	Lamp Wattage: 25 No. Lamps::	2
тапр туре, сопратитов	Sterl + Electricitic Ballast	naidiat <u>s</u> . 14016	jsvalouitg. marita	
R	Laundry	: Lighting		
Surface Reflection: List	Limination Type: Direct	No.Luminations:2	Lamp Wattage: 25 [No.Lamps:)	2
Lamp Type: Compact Fluore	scent + Electronic Ballast	Dimming: None	Switching: Marual	
	Bed 3:1	ighting		
Consumption: 6132	Type: Bedmon	Lengh: 3.52	Walth: 3.52 Height: 2.4	0
Surface Reflection: Light Lamn Type: Compact Fluore	Lumination Type: Direct. scent + Electurnic Ballast	No.Luminations:2	Lamp Wattage: 25  No.Lamps::  Switching: Marual	2
Conservation: 0.00	Rumpus Rump: Other/daytimensage)	:Lighting Ionath:400	NMM 4 66 Neishe 2 4	0
Surface Reflection: Light	Limitation Type: Direct	No.Luminations:2	Lamp Wattage: 25 No.Lamps:	ž
Lamp Type: Compact Finore	scent + Electronic Ballast	Dimming: None	Switching: Marual	
	Family / Me	als: Lighting		
Consemption: 122.64 Surface Reflection: Light	Type: Long	Lengh: 526	Waltin: 5.56 Height 2.4	0
Lamp Type: Compact Fliore	scent + Electronic Ballast	Bimming: Nore	Switching: Marual	4
	771 1			
Consumption: 122.64	Ritchen: Rype: Living	Laghting Lengh: 2.9	Walth: 2.59 Height 2.4	0
Sunface Reflection: Light	Lumination Type: Direct	No.Luminations:2	Lamp Wattage: 25 No.Lamps::	2
паний турь: сопрятьнов	STATE A FRANCISCO DE LA COMPANIA DE	LENDING'S. MORE	p we comg : manual	
<b></b>	Kitchen:	Lighting		
Consumption: 163.52 Surface Beflection: Lisht	Type: Kitchen Lumination Type: Direct	Length: 2.59	Walth: 2.59 Height 2.4 Lamm Wattage: 25 No Lamms: 1	2
Lamp Type: Compact Finore	scent + Electronic Ballast	Dimming: None	Switching: Marual	-
	Lamon	Linkting		
Consumption: 0.00	Lounge: Type: Other(daytimeusage)	Lengh: 4.80	Widhih: 4.80   Height: 2.4	0
Surface Reflection: Light Lamn Type: Compact Floor	Lumination Type: Direct scent + Electronic Ballact	No.Luminations:2	Lamp Wattage: 25 No. Lamps :: Switching: Manual	2
			processing, restand	
Longarombers: 1111	Entry: ]	Lighting	Diadobi K 16 - Diamater 110	
Surface Reflection: Light	Limitation Type: Direct	No.Lumirations:2	Lamp Wattage: 25 No. Lamps:	2
Lamp Type: Compact Filtore	scent + Electronic Ballast	Bimming: Nore	Switching: Marual	
	Bedmon Con	ridor: Lighting		
Consumption: 0.00	Rype: Other(daytimeusage)	Lengh: 2.30	Walth: 2.30 Height: 2.4	0
Sufface Reflection: Light Lamp Type: CompatiFilion	scent + Electronic Ballast	No. Luminations (2 Dimming: None		4
			I	

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<sub>2</sub>-e emissions are calculated from the electricity CO<sub>2</sub> intensities appropriate to the postcode.
- A new lighting report page has also been added to AccuRate's summary report, showing annual energy consumption, CO<sub>2</sub>-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.

### REFERENCES

- 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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