

Intelligent Lighting

Scope

The scope of this exercise was to produce the calculations required to be able to quantify the Return of Investment resulting from installing Intelligent Lighting Systems which dim and/or switch off the lights during pre-programmed periods.

Overview

The calculation is modular, based on a number of Lighting Zones. The user inputs the variables listed in Table 1. Variables i1 to i3 describe the current system. The proposed intelligent dimming system is described using Variables i4 to i9. Three power levels are used:

1. Lights on at full power,
2. Lights at Dimmed Power Level 1,
3. Lights at Dimmed Power Level 2.

Should the intelligent system switch off the lights during a given period, one of the Dimmed Power Levels is set at 0%.

Input variables i1 to i8 are inputted for the different zones (numbered 1 to n).

Variable No	Input Variable	Symbol	Unit
i1	Installed Lighting Power – Zone N	P_{100N}	kW/zone
i2	No of similar zones	Z	No
i3	Current utilisation	t_c	hrs/day
i4	Dimmed Power Level 1	D_1	%
i5	Dimmed Power Level 2	D_2	%
i6	Proposed Utilisation time at Full Power	t_{100}	hrs/day
i7	Proposed Utilisation time at Dimmed Power Level 1	t_1	hrs/day
i8	Proposed Utilisation time at Dimmed Power Level 2	t_2	hrs/day
i9	Dimmer Efficiency	D_{eff}	%

Table 1: Required Inputs – Intelligent Lighting System

The user inputs the costs in financial variables fi1 to fi4 (listed in Table 2) and defines the discount rate and the required Return of Investment (ROI) period in variables fi5 and fi6 respectively. The appropriate electricity tariff is defined in variable fi7. The tariffs are shown in Appendix 1: Enemalta Tariffs.

Variable No	Input Variable	Symbol	Unit
fi1	Dismantling Cost	C_1	€
fi2	Disposal Cost	C_2	€
fi3	Capital Cost	C_3	€
fi4	Installation Cost	C_4	€
fi5	Discount Rate	i	%
fi6	ROI period	R	Years
fi7	Electricity Tariff	r	€/kWh

Table 2: Required Inputs – Financial

The algorithm calculates and presents the outputs listed in Table 3 and Table 4.

The total installed lighting power for Zone N and for all the zones are outputted in Variables o1 and o2. The current, proposed and saved electricity consumption and corresponding costs are calculated in variables o3 to o12 and fo1.

The Return of Investment and the Payback period (variables fo3 to fo6) are calculated based on the savings (variable fo1) and the total investment cost (variable fo2).

Variable No	Output Variables	Symbol	Unit
o1	Total Installed Lighting Power – Zone N	P_{tN}	kW
o2	Total Installed Lighting Power	P_t	kW
o3	Current Electricity Consumption – Zone N	E_{CN}	kWh/day
o4	Proposed Electricity Consumption – Zone N	E_{PN}	kWh/day
o5	Electricity Consumption Savings – Zone N	E_{SN}	kWh/day
o6	Percentage Electricity Savings – Zone N	S_N	%
o7	Total Annual Current Electricity Consumption	E_C	kWh/year

o8	Total Annual Current Electricity Cost	C_c	€/year
o9	Total Annual Proposed Electricity Consumption	E_p	kWh/year
o10	Total Annual Proposed Electricity Cost	C_p	€/year
o11	Total Annual Electricity Consumption Savings	E_s	kWh/year
o12	Percentage Electricity Savings	S	%

Table 3: Calculated Outputs

Variable No	Output Variables	Symbol	Unit
fo1	Total Annual Electricity Cost Savings	C_s	€/year
fo2	Total Investment Cost	C_t	€
fo3	Pay Back Period - Simple	t_{SPB}	years
fo4	Pay Back Period - NPV	T_{NPV}	years
fo5	ROI after R years	ROI_R	€
fo6	Percentage ROI after R years	$ROI_{R\%}$	%

Table 4: Calculated Outputs - Financial

Conclusion

A preview with four zones and dummy values is shown in Appendix 2. The number of zones can be increased accordingly.

Appendix 1: Enemalta Tariffs

Band	Cumulative Consumption (kWh)	Tariff (€/kWh)
1	0 - 2,000	0.1215
2	2,001 - 6,000	0.1275
3	6,001 - 10,000	0.1373
4	10,001 - 20,000	0.1485
5	20,001 - 60,000	0.1613
6	60,001 - 100,000	0.1500
7	100,001 - 1,000,000	0.1403
8	1,000,001 - 5,000,000	0.1275
9	5,000,000 & over	0.1080

Zone Number	Similar Zones	Installed Lighting Power		Current Utilisation	Proposed Utilisation			Dimmed Power Level 1	Dimmed Power Level 2	Current Energy Consumption	Proposed Energy Consumption	Energy Savings	
					@ Full Power	@ Dimmed Power Level 1	@ Dimmed Power Level 2						
					z	P _{100N}	P _{TN}						
No	kW/Zone	kW	hrs/day	hrs/day	hrs/day	hrs/day	%	%	kWh/day	kWh/day	kWh/day	%	
1	2	3.5	7	24	16	4	4	50	15	168	144.7	23.3	13.9
2	20	2	40	12	8	4		20		480	391.1	88.9	18.5
3	3	5	15	20	16	8		0		300	266.7	33.3	11.1
4	2	10	20	24	16	4	4	50	0	480	400.0	80.0	16.7
		TOTAL	82							1428	1202	226	15.8

INPUTS

Cost Item	Symbol	Value	Unit
Dimmer Efficiency	D _{eff}	90	%
Dismantling Cost	C ₁	0	EUR
Disposal Cost	C ₂	0	EUR
Capital Cost	C ₃	30,000	EUR
Installation Cost	C ₄	3,000	EUR
Discount Rate	i	2.00	%
ROI period	R	4	years
Electricity Tariff	r	0.1403	EUR/kWh

OUTPUTS

Cost Item	Symbol	Value	Unit
Total Installed Power	P _t	82	kW
Total Investment Cost	C _t	33,000	EUR
Current Electricity Consumption	E _C	521,220	kWh/year
	C _C	73,127	EUR/year
Proposed Electricity Consumption	E _p	438,892	kWh/year
	C _p	61,577	EUR/year
Electricity Consumption (savings)	E _s	82,328	kWh/year
	C _s	11,551	EUR/year
	S	15.8	%
Pay Back Period	Simple	t _{SPB}	2.86 years
			34.3 months
	NPV	t _{NPV}	2.97 years
			35.7 months
Return of Investment after year no. R (using NPV)	ROI _R	10,982	EUR
	ROI _{R%}	33.3	%