UNIVERSITÀ POLITECNICA DELLE MARCHE

"Potential energy savings deriving from the lighting system renovation in a community clinic"

A. Carbonari, L. Nobili, R. Pontoni
(speaking)

DICEA Department - Division of Building Technologies

Research Team: Building Construction and Automation

www.univpm.it

Polytechnic University of Marche - Ancona, Italy

Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

OUTLINE

- Objective: EPC contracting
- The case study: a community clinic
- Measured consumption and energy breakdown
- Future scenarios
- Simulations
- Opportunities
- Assessment of energy savings and payback
- Conclusions

Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

OBJECTIVE

EU Directive 2012/27/EU: public administration's energy improvement.

EPC: Energy performance contracting

Consumption of public buildings is so high that some renovation scenarios have a very short payback period and can be managed directly by facility management companies.

From literature:

- lighting usually represents between 20% and 30% of the overall electric consumption;
- savings opportunities using daylight illumination have been estimated between 20% and 80% of ligthing consumption.

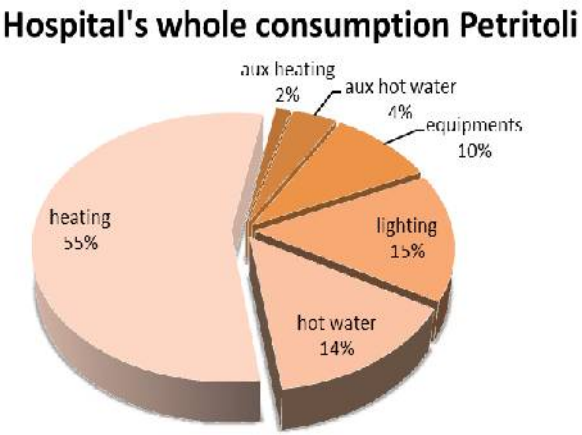
OUR CASE STUDY

Petritoli's Community Clinic, near Fermo (Italy).

Net surface: 3807 m2
Gross volume: 18676 m3
Centralized heating plant
It hosts: radiology, emergency, physiotherapy, medical offices, psychiatric ward, hospitalization (20 beds).

OVERALL ENERGY BREAKDOWN (measured)

Comparison in terms of primary energy:



Electric power consumption:

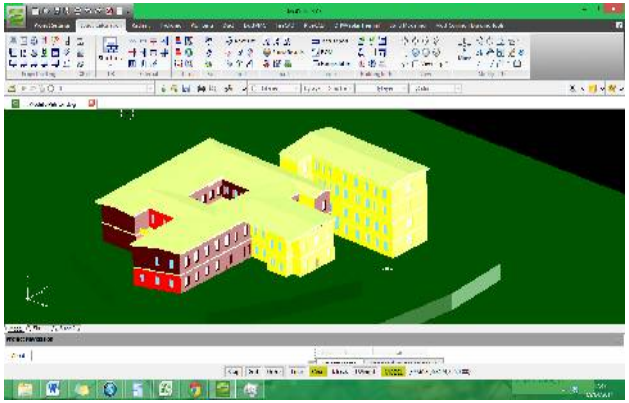
YEAR/MONTH III	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1 - Fuel Consumption Gas Methane [m³]													
2011	7384	10091	7491	3210	1106	904	792	633	R39	1109	3051	9726	4R332
2012	6309	9657	7660	5383	934	904	752	601	787	1053	4795	9329	4R130
2013	59R6	9163	7268	510R	R96	905	771	631	667	965	4R15	9309	464R4
2. - Fuel Consumption for Hot Water [m³]													
2011	R96	R96	R96	R96	1106	904	792	633	R39	1109	R96	R96	10747
2012	R01	R01	R01	R01	R06	R06	752	601	787	1053	R01	R01	96607
2013	R06	R06	R06	R06	R96	905	771	631	667	965	R06	R06	96770
3. - Fuel Consumption for Heating [m³]													
2011	64R9	9192	6595	3314							4156	RR31	375R0
2012	550R	RR56	6R59	45R3							3903	R42R	3R228
2013	51R0	R357	6463	4302							4009	R503	36R14
4. - Electrical Power Consumption [kWh/a]													
2011	12R49	5180	52R2	7419	9016	7096	7033	0	9991	5010	5719	69RR	R15R3
2012	R506	R264	7210	6478	5544	5344	5563	5357	53RR	5974	7441	R064	79133
2013	R341	7431	4152	7431	5640	5379	5600	58R6	574R	65R3	R026	6350	764R7
5 - Total Primary Energy [kWh]													
2011	74610	100R7	75634	33751	12755	10R16	9742	R220	10101	12780	52226	970R0	49R295
2012	642R1	96414	77253	54603	98R4	98R4	9353	7909	9694	13236	49748	92308	493R57
2013	61195	91676	73494	51961	10740	10R26	9540	R197	R543	11402	49559	93076	48R60R

Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

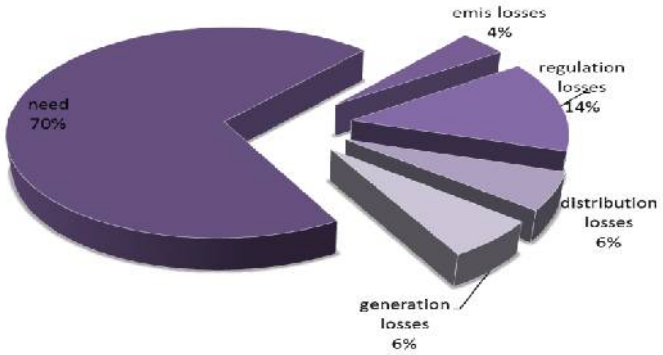
THERMAL ENERGY BREAKDOWN (simulated)

Software used for simulation: MC4Suite2013

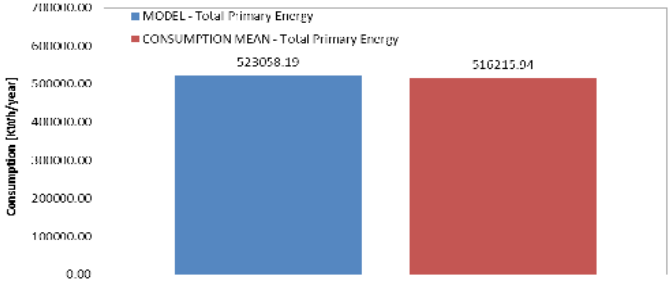
Calculation methods: UNI TS 11300-1 (from UNI EN ISO 13790:2008) and UNI TS 11300-2 .



Thermal plant:
on the ground floor (centralized).
Boiler: Biasi AR250 (290 kW).
A tank for hot water storage.
Two circuits (heating/hot water).



Validation (< 1% error):



ELECTRIC ENERGY BREAKDOWN (simulated)

From behavioral models (data source: interviews and on-site surveys; implementation: Excel spreadsheet):

YEAR\MONTH	*JEN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*	*TOTAL*
1 – Electrical Power Consumption [kWh_{el}]													
2011-12-13 Mean	8666	8420	7346	6600	5648	5445	5668	5458	5489	6086	7581	8216	80622
2. – Auxiliary Consumption for Heating [kWh_{el}]													
2011-12-13 Mean	1111.7	1111.7	1111.7	555.8							1111.7	1111.7	6114.2
3. - Auxiliary Consumption for Hot Water [kWh_{el}]													
2011-12-13 Mean	807.8	807.8	807.8	807.8	807.8	807.8	807.8	807.8	807.8	807.8	807.8	807.8	9694.1
4 – Building Electrical Power Consumption [kWh]													
2011-12-13 Mean	7059	6812	5738	5338	4733	4529	4752	4542	4754	5171	5974	6608	65827
5 – Equipment Electrical Power Consumption [kWh]													
2011-12-13 Mean	2113	2113	2113	2113	2113	2113	2113	2113	2113	2113	2113	2113	25352
6 – Lighting Electrical Power Consumption [kWh]													
2011-12-13 Mean	4946	4699	3625	3226	2620	2416	2639	2429	2461	3058	3861	4496	40475

Database about lighting: fixtures; lamps; power; socket; control gear; daily use; weekly use; monthly use; monthly consumption; annual consumption.

Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

RENOVATION SCENARIOS FOR LIGHTING

List of combinations:

Scenario Code	Description
SC1+2 (scenarios no. 1 and 2)	- low occupancy rooms: ballast replacement (Scenario no. 1) - high occupancy rooms: DALI control system with new LED luminaires (Scenario no. 2)
SC1+2+3	- high occupancy rooms: DALI control system with new LED luminaires (Scenario no. 2) - low occupancy rooms: ballast replacement (Scenario no. 1) for areas that need to maintain the same lighting level (e.g. medical offices); - Re-lamping with new LED lamps (Scenario no. 3) for rooms where no restrictions are imposed to the lighting level (e.g. bathrooms, technical rooms)
SC2A	- Limited to corridors: DALI control system with new LED luminaires (Scenario 2)

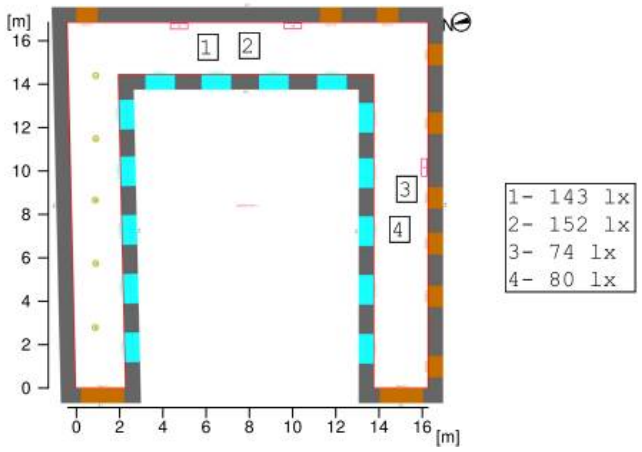
Simulations allowed to assess how effective each of the combinations may be, as compared to the measured and simulated current electric consumption due to lighting.

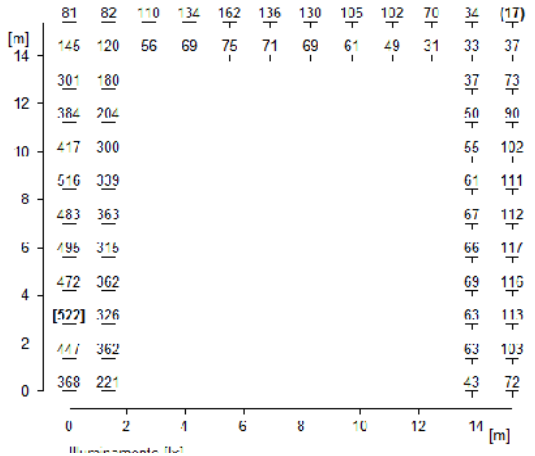
Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

LIGHTING MODELLING

Software used for simulation: Relux
Calculation methods: Radiosity algorithm.

Experimental model calibration (lux-meter point measurements).
Adjustment of parameters: walls reflectivity, transmission coefficient of windows.



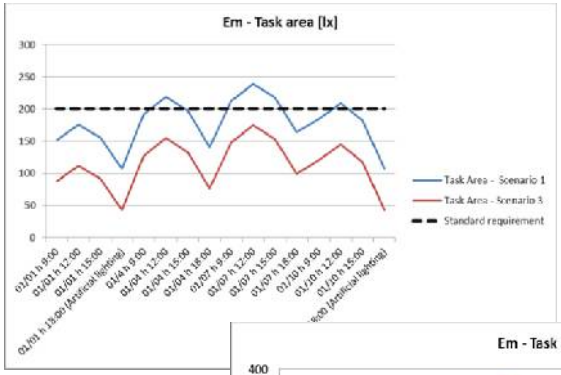


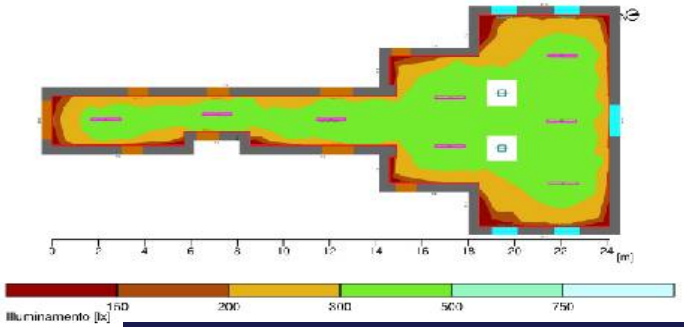
Requirements: thresholds for lighting levels; luminance uniformity in order to avoid glare.

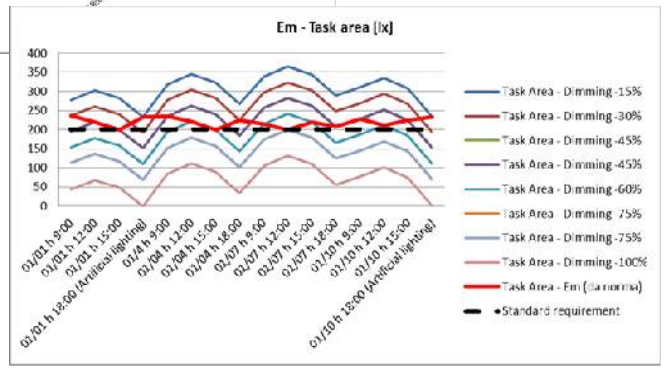
Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

SIMULATION PHASE

Current lighting levels will be guaranteed in task areas even after renovation has been accomplished; dimming was used to adjust lamps' power according to real needs (i.e. natural lighting and deployment of fixtures). Energy savings were derived from operation time and actual power of new lamps.







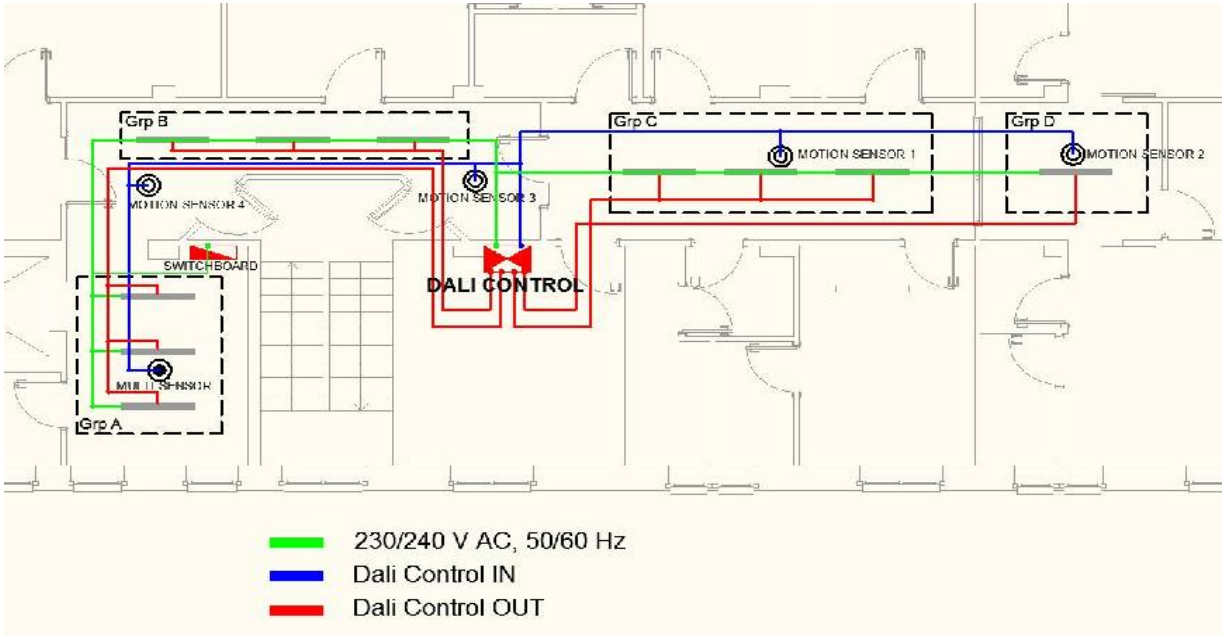
ESTIMATED ENERGY SAVINGS

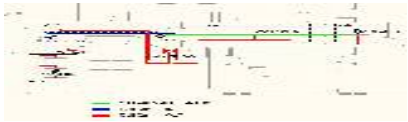
Scenarios no. 1 and 3 were called “soft” scenarios: ballast replacement and lamping replacement.

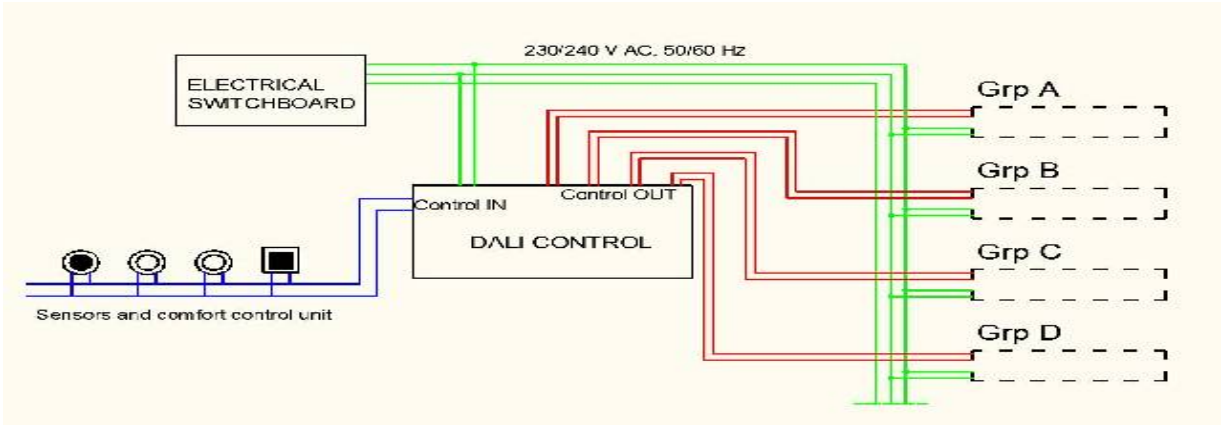
Scenario no. 2 was called “hard” scenario: replacement of lamps with led fixtures and Dali control of the dimming level.

Scenario	Current consumption [KWh]	Scenario consumption [KWh]	Saving [KWh]	Saving %	Renovation Cost [€]
Scenario no. 1	58783	50740	8043	13.68%	6359
Scenario no. 2 (13011:1974)	58783	31102	27681	47.09%	82699
Scenario no. 2 (EN12464-1)	58783	37983	20800	35.38%	82699
Scenario no. 2A (13011:1974)	58783	40431	18352	31.22%	49538
Scenario no. 2A (EN12464-1)	58783	43365	15418	26.23%	49538
Scenario 3	58783	23210	35572	60.52%	24355
Scenario 1+2 (13011:1974)	58783	35370	23413	39.83%	55897
Scenario 1+2 (EN12464-1)	58783	35332	23451	39.89%	55897
Scenario 1+2+3 (13011:1974)	58783	32253	26530	45.13%	80253
Scenario 1+2+3 (EN12464-1)	58783	35332	23451	39.89%	80253

IMPLEMENTATION OF THE DALI CONTROL







Luminaire Groups: 4

Motion Sensors : 4

Multi Sensors : 1

Dali Control : 1

Led Dimmable Fixtures : 10

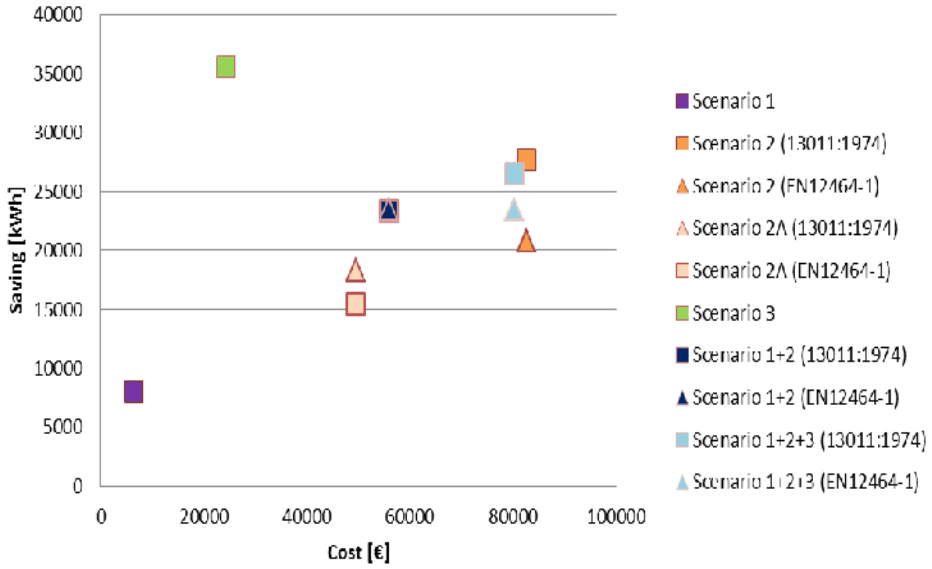
Cost (Including Manpower) : 58.41 €/m2

Carbonari, Nobili, Pontoni - Università Politecnica delle Marche, DICEA, Ancona, Italy

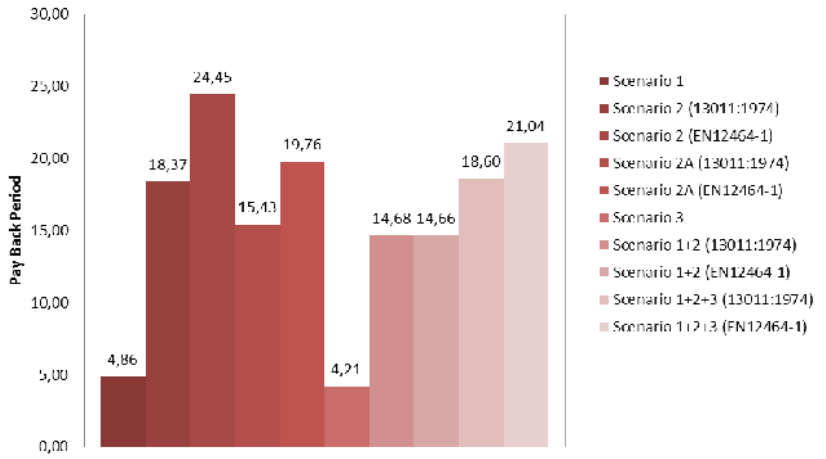
COST OF LIGTHING RENOVATION

Average cost of scenario no. 1: 2.40 €/m2.
Average cost of scenario no. 2: 58.41 €/m2.
Average cost of scenario no. 3: 7.59 €/m2.

Savings vs renovation cost



Discounted payback period



CONCLUSIONS

1. "Soft" scenarios have short payback periods but also low energy savings;
2. "hard" and combined renovations scenarios have longer payback periods but they will guarantee higher energy savings and the installation of an almost completely renewed lighting system, so they are worth the investment.

Thank you for your kind attention

A. Carbonari, L. Nobili, R. Pontoni

DICEA Department - Division of Building Technologies

Research Team: Building Construction and Automation

www..univpm.it

Polytechnic University of Marche - Ancona, Italy