eurac research

Towards improved feasibility study of artificial light efficiency measure in buildings

Eurac Research

Agenda

1. Background
2. Method
3. Results
4. Conclusions

Background

ITA1084 - IHNES

Interregional Hospital Network for Energy Sustainability

IHNES promotes the topic of energy efficiency and energy management in the health sector through an interregional network of hospital operators, research institutions and engineering offices.

Background

Partners

Syneco

Eurac Research

Inewa

Azienda sanitaria Bolzano (SABES)

Landeskrankenhaus Salzburg (SALK)

Krankenhaus Innsbruck (Tirol Kliniken)

Azienda sanitaria Trieste (ASUITS)

Background

Rewamping of artificial light system → Electricity savings → € savings

Target

Reducing artifical light consumption ΔEl

- Effect on heating comsumption -> $\Delta H = \Delta El * C_h$

  $C_h = \Delta H / \Delta El$

- Effect on cooling comsumption -> $\Delta C = \Delta El * C_c$

  $C_c = \Delta C / \Delta El$

Method – Hypothesis

Simulation with UNI EN 52016

- 7 types of buildings
- 113 different climates
- 2 levels of efficiency of the building
- 2 thermal mass of the envelope
- 4 levels of light efficiency

3616 simulations per building

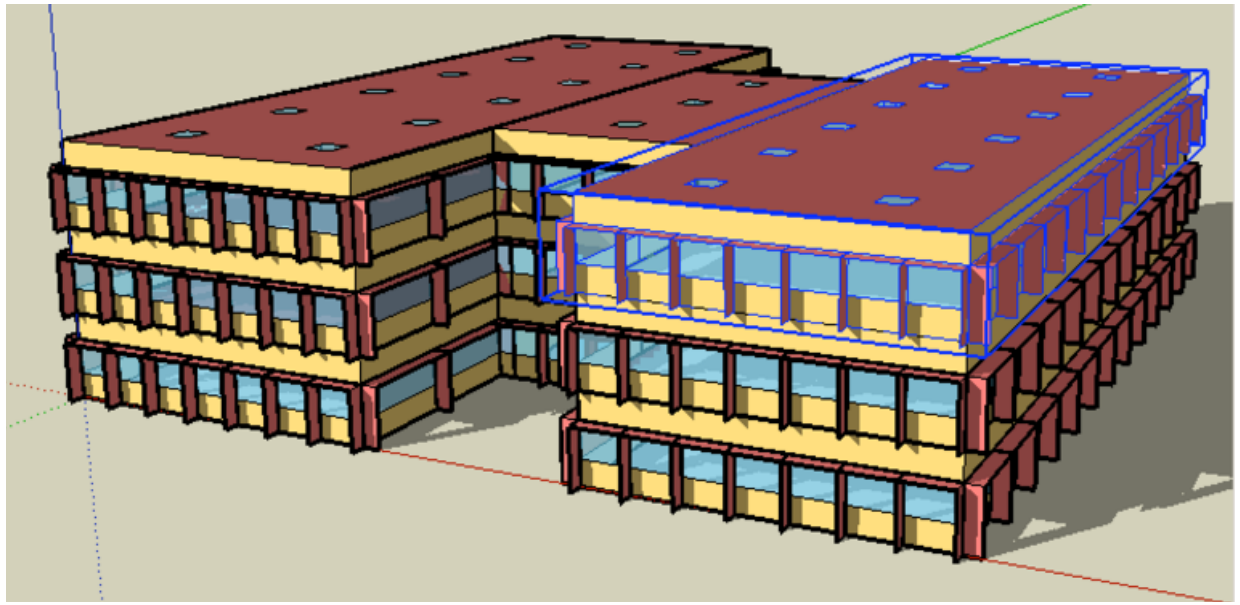
25312 total simulations

Method – Building types

Geometry defined by the U.S. Department of Energy (DOE)

The building category studied:

1. Hospital
2. Large Office
3. Medium Office
4. Outpatient Health Care
5. Midrise Apartment
6. Secondary School
7. Small Hotel



Method – Climates

HeatingDegreeDays

From 6 HDD (La Frontera)

to 5600 HDD (Warth)

CoolingDegreeDays

From 0 CDD (Alps & Nord Sea)

to 647 CDD (Arnesano)

Global Radiation

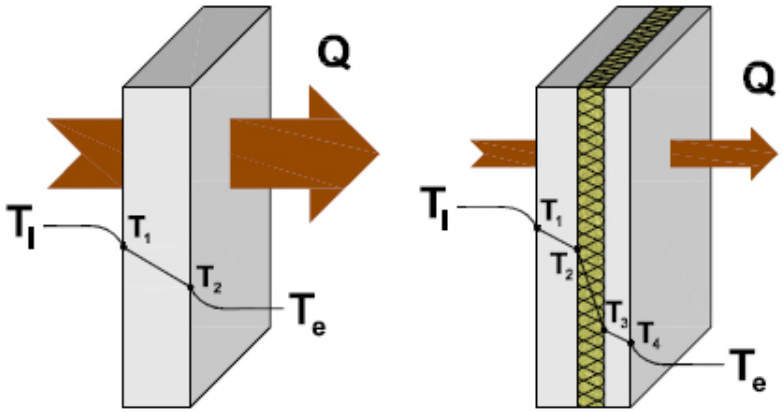
From 948 kWh/m²a (Enschede)

to 1969 kWh/m²a (Zahara)

Method – building efficiency

Two different configuration: high - low

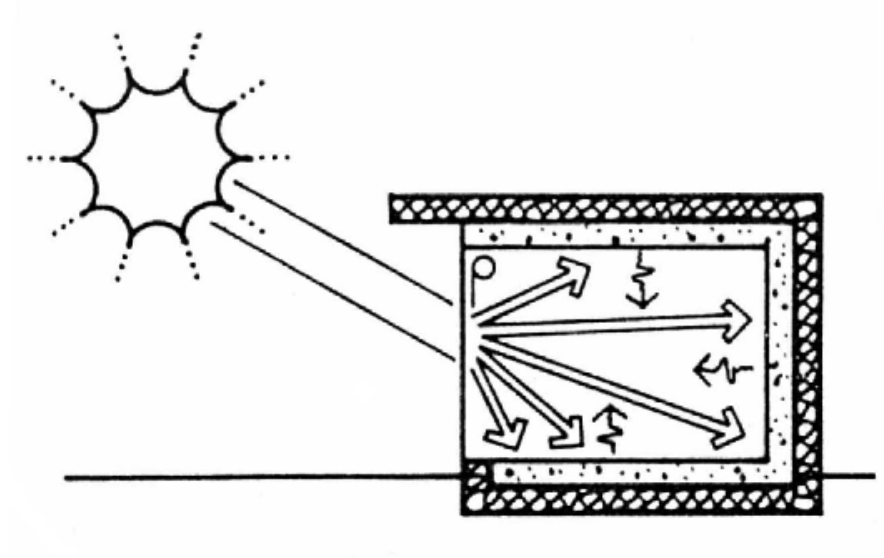
Building efficiency				
	low		high	
Trasmittance of envelope				
Ground floor	0.42	W/(m²K)	0.14	W/(m²K)
Walls	0.56	W/(m²K)	0.19	W/(m²K)
Windows	2.49	W/(m²K)	1.10	W/(m²K)
g value windows	0.90	W/(m²K)	0.70	W/(m²K)
Roof	0.88	W/(m²K)	0.29	W/(m²K)
Ventilation				
Heat recovery	0	%	50	%



Method – Building thermal mass

Two different walls thermal mass

	High thermal mass		Low thermal mass	
Walls thermal mass	476000	J/(m²K)	178512	J/(m²K)



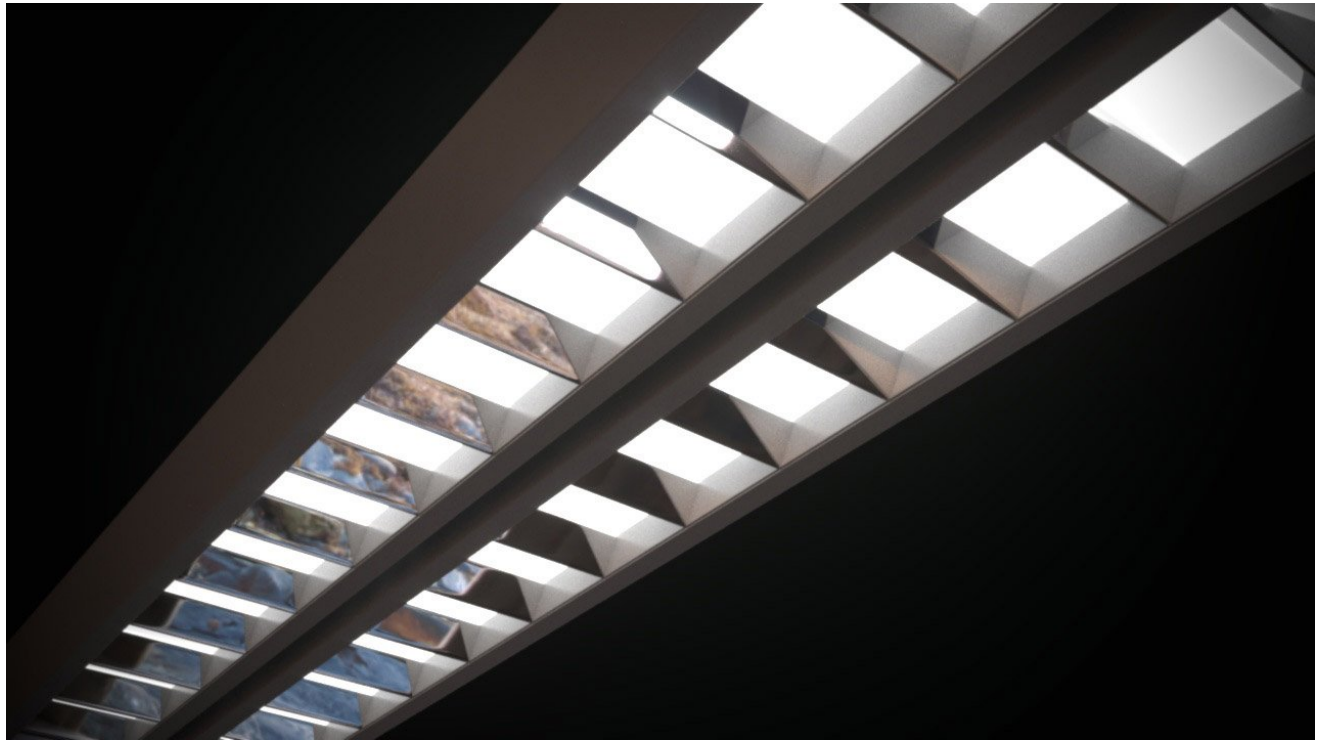
Method – Artificial light

Efficiency

4 levels of efficiency

Control strategy, light on when:

1. Building occupied
2. Occupants are not sleeping
3. Average radiation in the façade < 400 W/m²



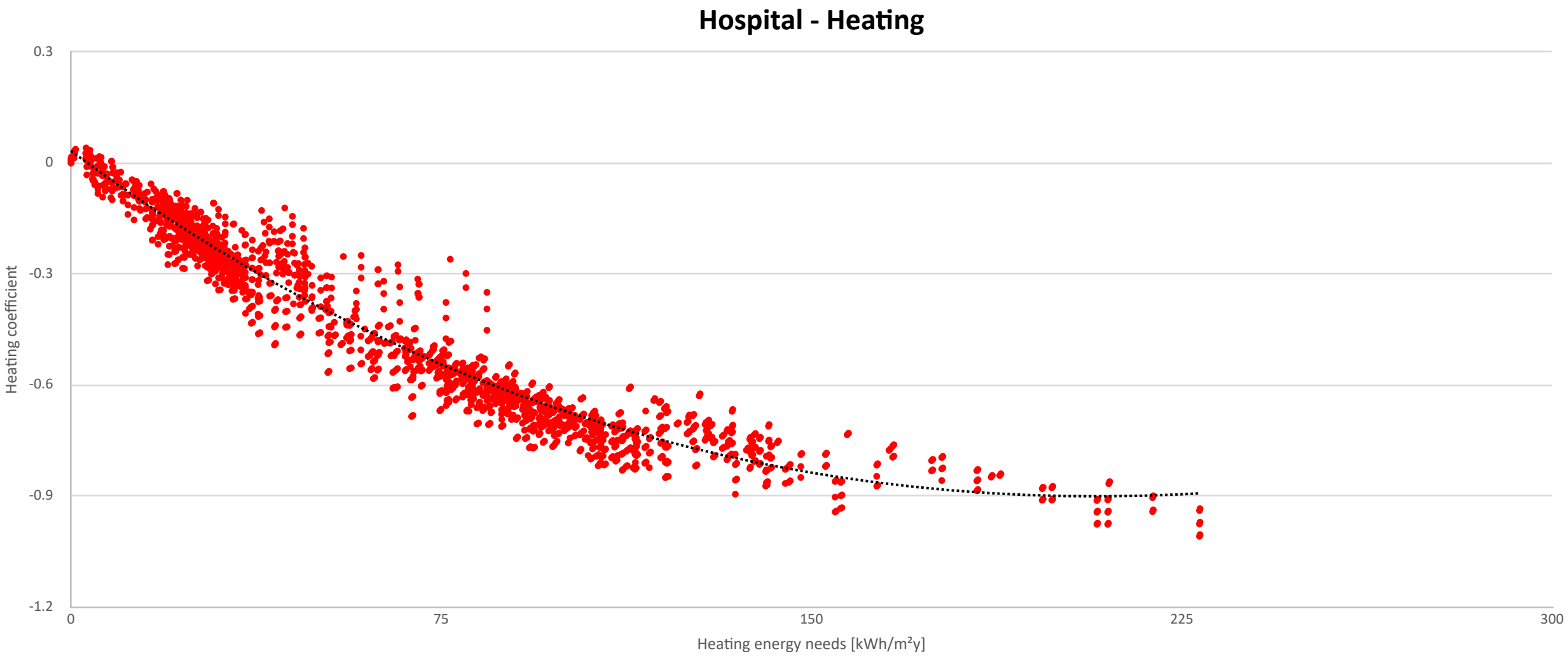
Results

We calculated 2 coefficient:

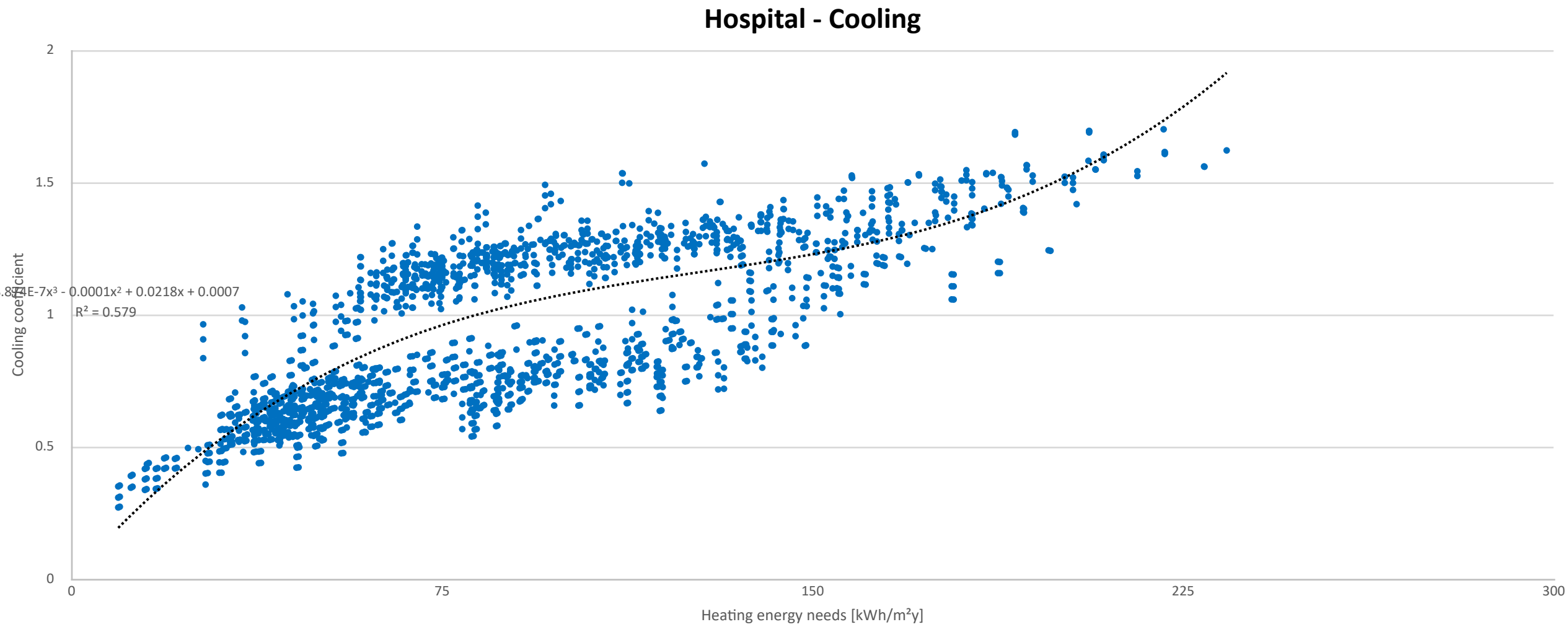
1. $C_h = \Delta H / \Delta El$ -> Heating Energy Need Savings/Electricity savings
2. $C_c = \Delta C / \Delta El$ -> Cooling Energy Need Savings/Electricity savings

$y = -1.994E\text{-}8x^3 + 3.024E\text{-}5x^2 - 0.0099x + 0.0327$

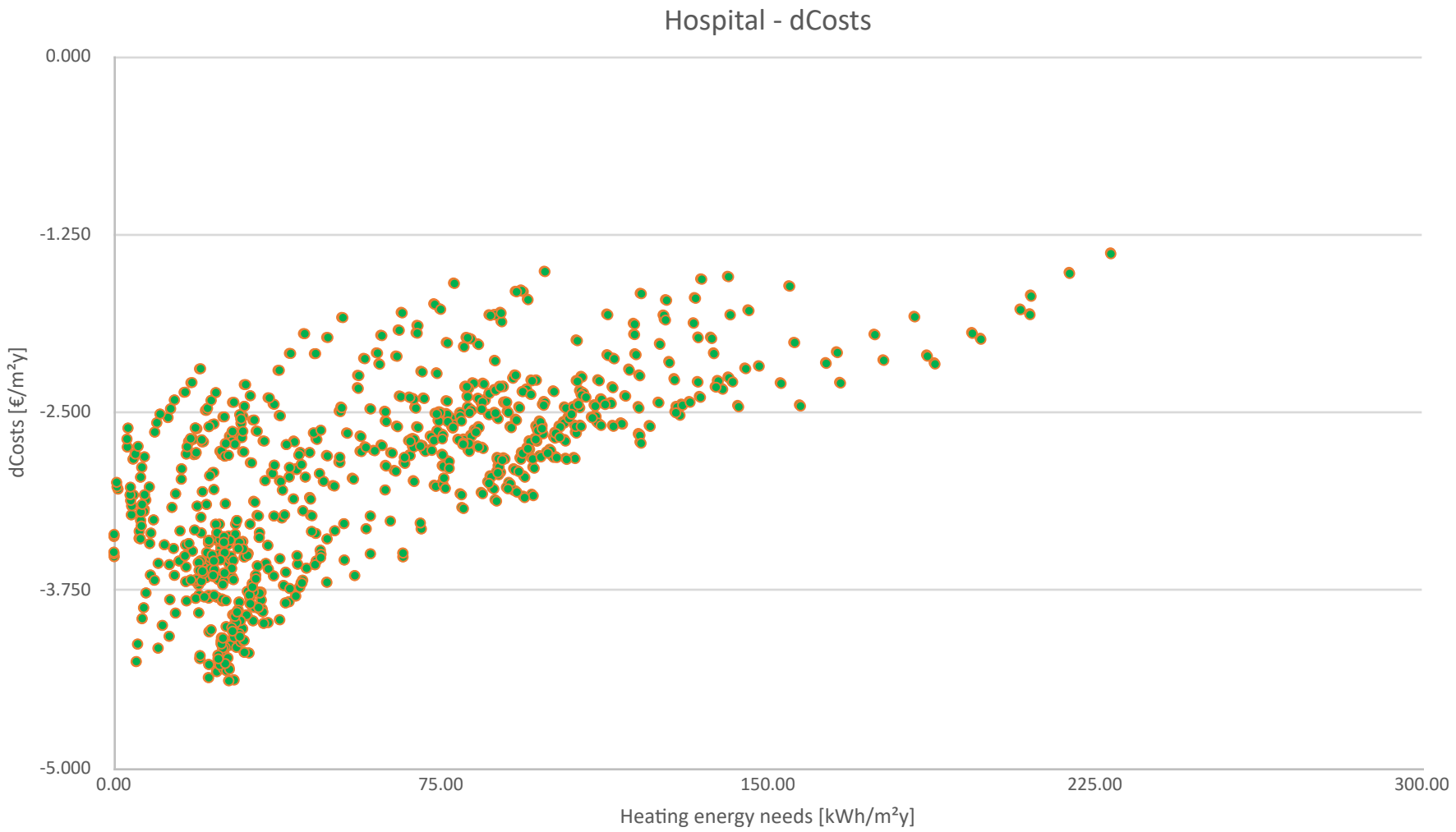
$R^2 = 0.9508$



Results - Hospitals



Results - Hospitals



Hypotesis		
SCOP	0.80	
SEER	3.00	
Price thermal energy	0.10	€/kWh
Price eletricity	0.25	€/kWh

We considered:

1. Electricity saving for lightning;
2. Increase of heating energy needs;
3. Decrease of cooling energy needs;

Results - Costs

dCosts considering lightning - heating - cooling [€/m²y]											
	heating energy need										
from [kWh/m²y]	0	15	30	45	60	75	90	105	120	135	150
to [kWh/m²y]	15	30	45	60	75	90	105	120	135	150	5000
Hospital	-3.26	-3.48	-3.35	-2.94	-2.58	-2.55	-2.57	-2.37	-2.21	-2.11	-1.95
Large office	-0.54	-0.35	-0.43	-0.41	-0.32						
Medium office	-0.46	-0.35	-0.32	-0.40	-0.40	-0.40	-0.35	-0.30			
Midrise Apartment	-0.12	-0.11	-0.10	-0.10	-0.09	-0.09	-0.08	-0.07			
OutPatient	-0.54	-0.52	-0.51	-0.41							
School	-0.25	-0.36	-0.32	-0.22	-0.25	-0.27	-0.35	-0.31	-0.32	-0.33	-0.24
Hotel	-1.31	-0.95	-0.92	-0.86	-0.84	-0.82	-0.71				

dCosts considering only lightning [€/m²y]											
	heating energy need										
from [kWh/m²y]	0	15	30	45	60	75	90	105	120	135	150
to [kWh/m²y]	15	30	45	60	75	90	105	120	135	150	5000
Hospital	-2.22	-2.64	-2.73	-2.58	-2.51	-2.69	-2.95	-2.94	-2.68	-2.77	-2.74
Large office	-0.49	-0.47	-0.62	-0.61	-0.52						
Medium office	-0.49	-0.45	-0.46	-0.60	-0.62	-0.62	-0.55	-0.52			
Midrise Apartment	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.15	-0.14			
OutPatient	-0.49	-0.63	-0.63	-0.54							
School	-0.30	-0.51	-0.47	-0.35	-0.40	-0.45	-0.62	-0.55	-0.57	-0.59	-0.45
Hotel	-1.02	-0.98	-1.02	-1.06	-1.07	-1.10	-1.09				

Hypotesis		
SCOP	0.80	
SEER	3.00	
Price thermal energy	0.10	€/kWh
Price eletricity	0.25	€/kWh

Results - Costs

Difference in rewards [€/m²y]											
	heating energy need										
from [kWh/m²y]	0	15	30	45	60	75	90	105	120	135	150
to [kWh/m²y]	15	30	45	60	75	90	105	120	135	150	5000
Hospital	47%	32%	23%	14%	3%	-5%	-13%	-19%	-17%	-24%	-29%
Large office	10%	-26%	-31%	-33%	-38%						
Medium office	-6%	-22%	-31%	-34%	-36%	-36%	-36%	-42%			
Midrise Apartment	-9%	-21%	-24%	-31%	-37%	-41%	-45%	-47%			
OutPatient	9%	-16%	-20%	-25%							
School	-17%	-29%	-32%	-36%	-39%	-39%	-43%	-43%	-43%	-44%	-47%
Hotel	28%	-3%	-9%	-18%	-22%	-26%	-35%				

Hypotesis		
SCOP	0.80	
SEER	3.00	
Price thermal energy	0.10	€/kWh
Price eletricity	0.25	€/kWh

Conclusions

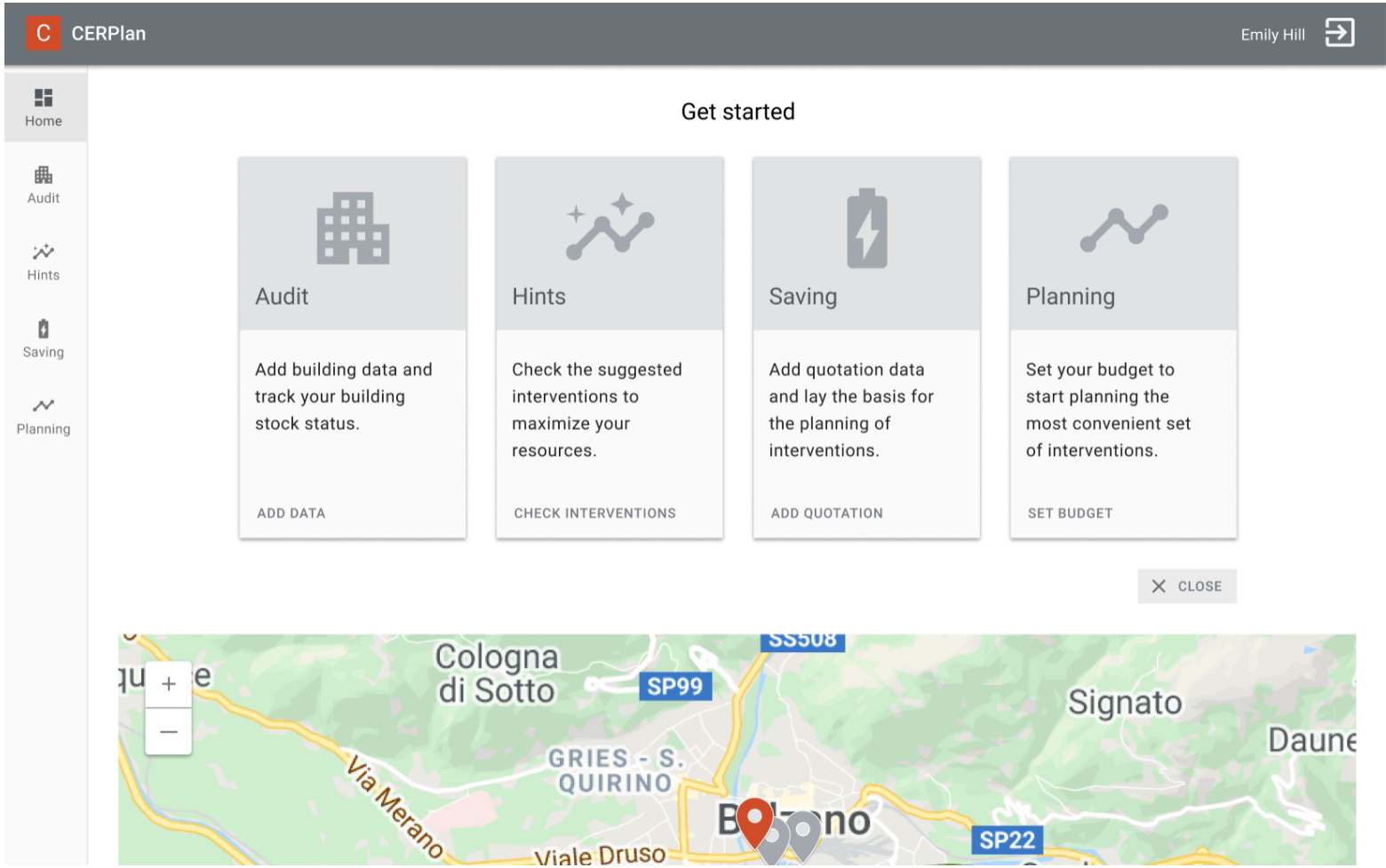
1. Rewamping of artificial light in a building has effect on heating and cooling consumption;
2. Each type of building has its own coefficient curves;
3. Cooling coefficient can be greater than 1 ;
4. Thermal mass does not influence the coefficient curves;
5. Buildings with low heating energy needs (hot climate, high efficiency) save more money then other buildings
6. In most of the cases that we considered the rewards are lower than expected considering only lighting

Conclusions – the CERPlan tool

CERPlan

Boost your building renovations

A tool to manage the energy requalification of a building stock considering energy saving and synergies with maintenance.



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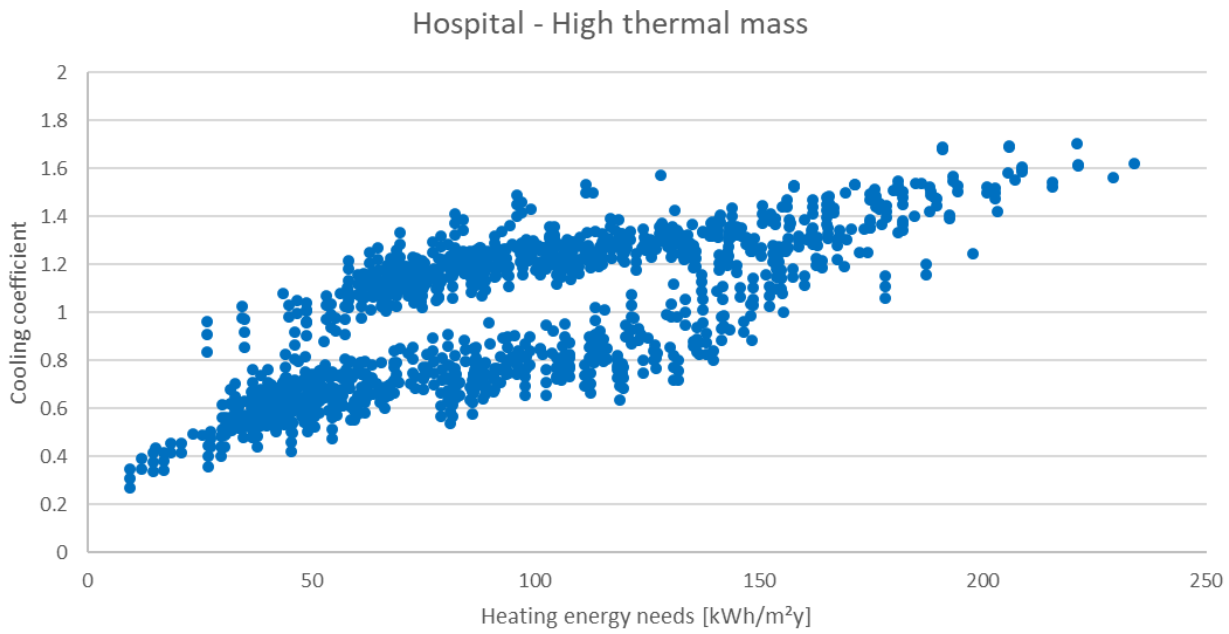
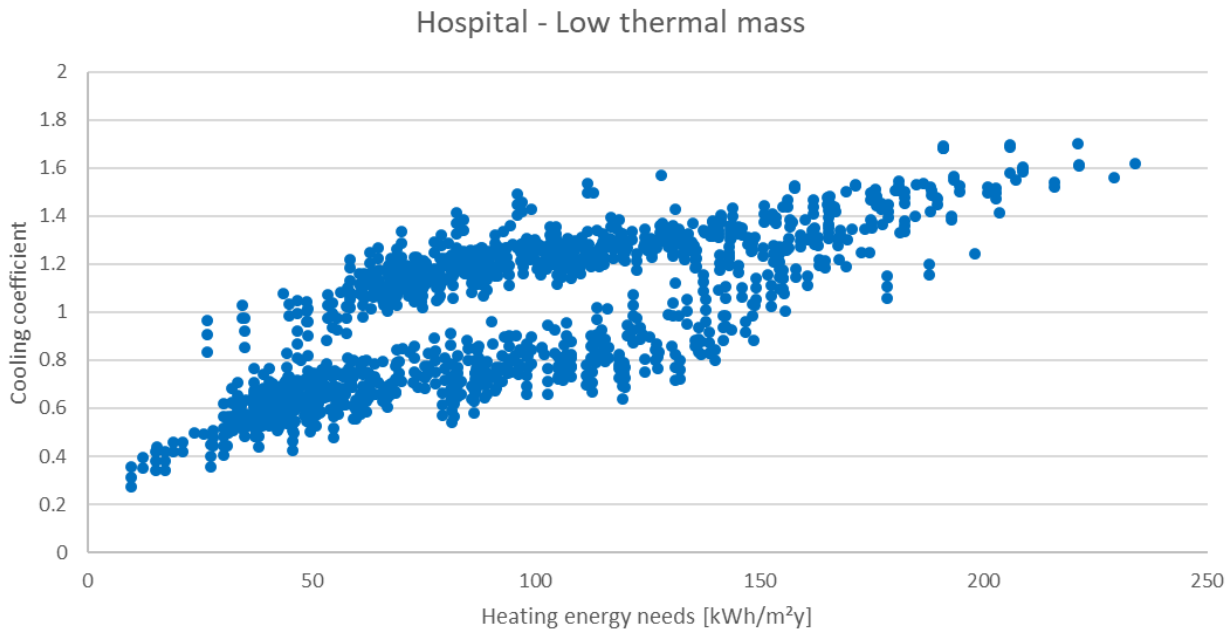
marco.castagna@eurac.edu
www.eurac.edu

Results - Hospitals





Results - Hospitals