UNIVERSITÀ POLITECNICA DELLE MARCHE

"Measured and estimated breakdown of energy consumption in a community clinic"

A. Carbonari, M. Giuliani, S. Ruffini, M. Lemma
(speaking)

DICEA Department - Division of Building Technologies

Research Team: Building Construction and Automation

www.univpm.it

Polytechnic University of Marche - Ancona, Italy

Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

OUTLINE

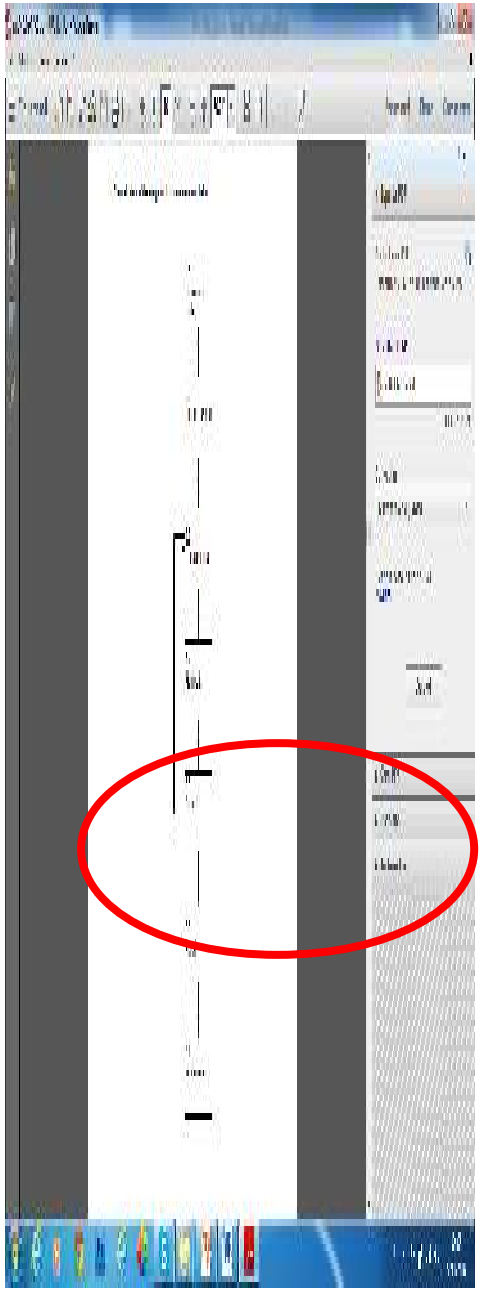
- Objective: energy audit of hospitals.
- Intermediate step: building's baseline.
- The case study: a community clinic
- Measured consumption and energy breakdown
- Approaches: standard dynamic simulation software vs lumped parameter modelling
- Outcomes from the first set of simulations
- Outcomes from the second set of simulations
- Discussion
- Conclusions

Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

OBJECTIVE

Energy audit's technical standard prEN16247-2:2014 suggests the procedure.

A crucial step is to set up a reliable **baseline** of the audited object.
A complete baseline cannot be inferred just from measurements, because these are usually relative to overall consumption figures.
So, measurements are usually enhanced by means of outcomes from **modelling**.



Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

THE BASELINE

- It splits the overall measured consumption into all its components;
- It represents the benchmark, and the input to assess the benefits provided by renovation scenarios;
- It helps perform building's diagnostics;

However:

- the reliability level varies according to the uncertainty affecting inputs;
- the more accurate this analysis is, the more detailed future scenarios' assessment will be.

Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

OUR CASE STUDY

San Elpidio a Mare's community Clinic, near Fermo (Italy).

Net surface: 5,040 m2
Gross volume: 22,029 m3
Central heating plant: 2 boilers: Ecomax NC 630 – 450 kW and RTQ 400 – 511 kW.
It is split into two blocks: block A1 hosts medical offices and wards (e.g. hospitalization, emergency, radiology); block A2 hosts staircases, elevators, waiting rooms.

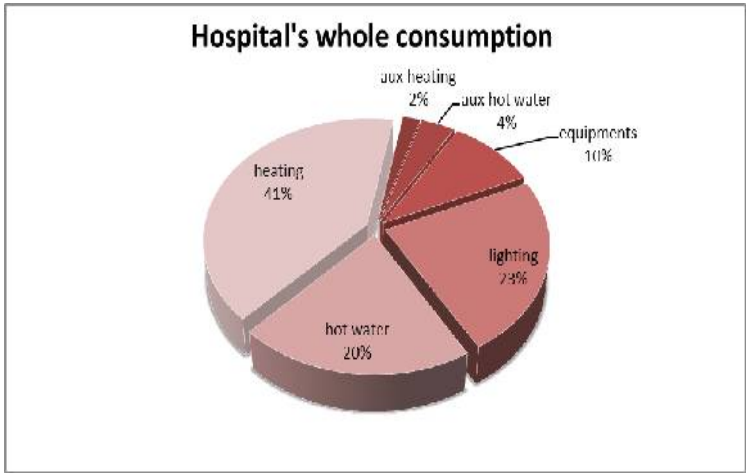
Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

OVERALL ENERGY BREAKDOWN (measured)

Comparison in terms of primary energy:

YEAR\MONTH	JEN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1 - Fuel Consumption Gas Methane [m^3]													
2012	18818	19756	10140	8731	2428	1880	1826	1641	1919	3494	6025	11027	87685
2013	7538	11292	7965	5313	18260	1790	1474	957	1050	1972	4852	7945	53974
2. - Fuel Consumption for Hot Water [m^3]													
2012	1939	1939	1939	1939	2428	1880	1826	1641	1919	1939	1939	1939	23267
2013	1512	1512	1512	1512	1826	1790	1474	957	1050	1512	1512	1512	18138
3. - Fuel Consumption for Heating [m^3]													
2012	16879	17817	8201	6792	0	0	0	0	0	1555	4086	9088	64418
2013	6026	9781	6454	3802	0	0	0	0	0	0	3341	6434	35835
4 - Total Primary Energy [kWh]													
2012	186125	195125	102864	87893	25966	20708	20192	18416	21083	36193	63383	111370	889317
2013	77811	113833	81912	55015	20106	19760	16728	11768	12660	21506	52045	81720	564864

Energy breakdown (including electricity):



Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

TWO APPROACHES FOR ENERGY MODELLING

1- Standard Dynamic simulation

Software: MC4Suite2013

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

It was used to work out the contribution by sub-categories (e.g. heating, hot water, auxiliary equipment, air leakages and ventilation …) to the overall consumption. Monthly energy balance.

2- Lumped parameters model

Software: DymolaTM – Modelica environment

Parametric, multidisciplinary and expandable model. It can manage to simulate advanced control systems.

Non-standard technical solutions can be simulated by developing new software code.

Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

LOOKING INTO THE SECOND MODEL

That was built using the "Modelica Buildings library v1.3".
Object-oriented, equation-based model, that is capable of simulating all the physical phenomena.
Currently a climatic control is implemented. Renovations scenarios shall include the use of the most advanced control systems.

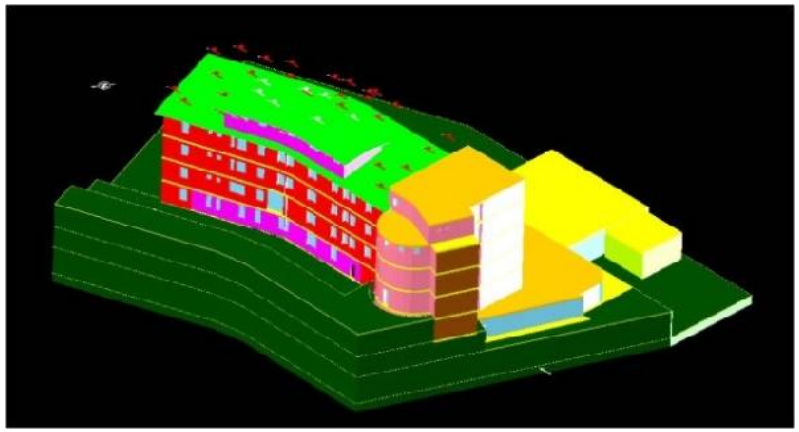
List of devices:

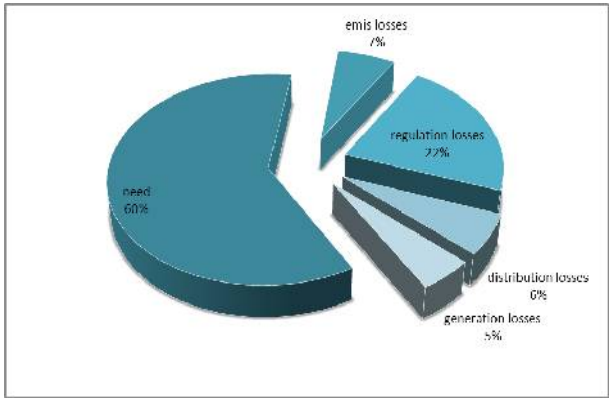
Pumps
Valves
Boilers
Control box
Sensors
Splits and mixers

Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

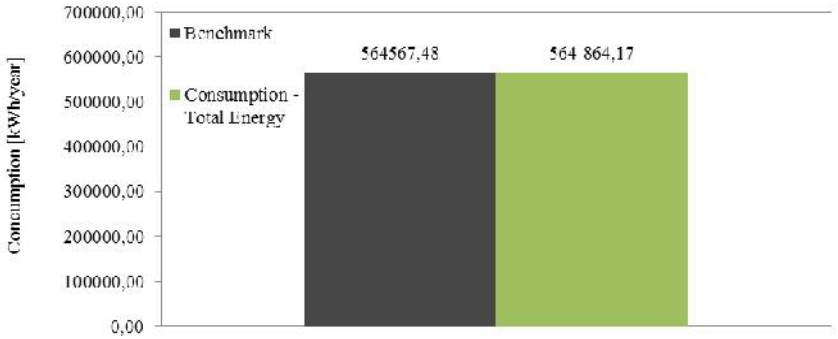
OUTPUTS FROM DYNAMIC SIMULATIONS

Breakdown into: thermal energy need on one hand, and generation, distribution, regulation and emission losses on the other hand.





Validation (error < 1%)

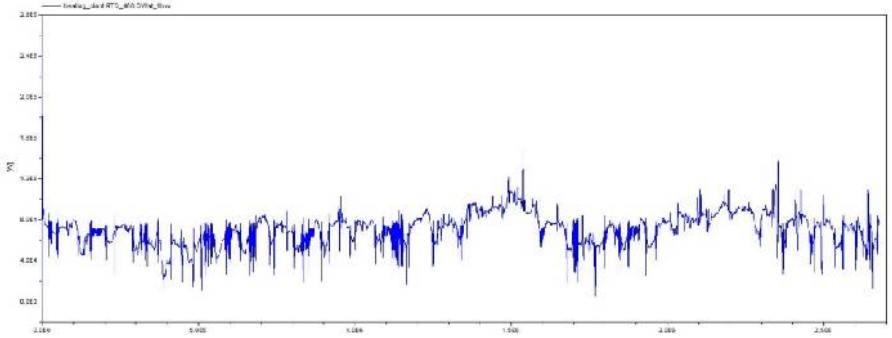


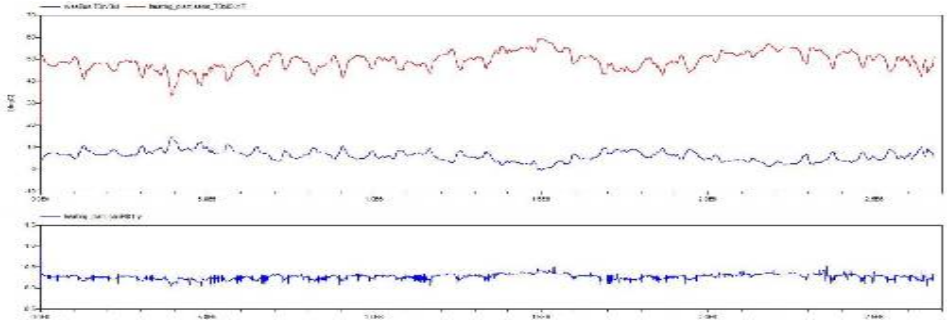
Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

OUTPUTS FROM LUMPED MODELLING

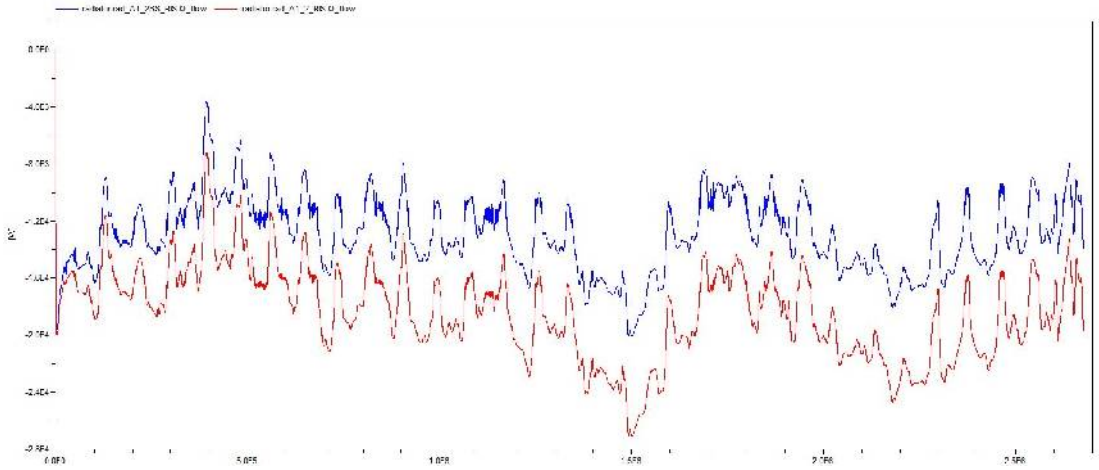
Examples (on a hourly time scale):

Boiler consumption, outdoor and supply water temperatures





Heat power emitted by radiators



Carbonari, Giuliani, Ruffini, Lemma - Università Politecnica delle Marche, DICEA, Ancona, Italy

DISCUSSION AND COMPARISON

1- Standard Dynamic simulation:	2- Lumped parameters model:
Faster	Complex and time consuming
Monthly energy balance	Detailed plot of variables
Coarse scale	More detailed
Standard systems and logics, usually those included in technical standards	Opportunity to implement potentially any kind of system and logics

CONCLUSIONS

1. Energy breakdown is usually derived from models;

2. In some energy audits, non standard renovation scenarios must be simulated, so new modelling opportunities should be envisaged;

3- Object-oriented equation-based software programs offer a great opportunity to simulate custom interventions.

Thank you for your kind attention

A. Carbonari, M. Giuliani, S. Ruffini, M. Lemma

DICEA Department - Division of Building Technologies

Research Team: Building Construction and Automation

www..univpm.it

Polytechnic University of Marche - Ancona, Italy