Energy Efficiency in buildings: a simple but accurate way to perform calculations

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Assessments in the following are based solely on the author's personal opinions.

- Energy efficiency assessments of buildings are often criticized for being too expensive. This is due, i.a., to the complexity of the International Standards on which they are based.
- For the application of these Standards, expensive software tools are needed, which increases the fee for the hired professional.

- “Simplified” methods are envisaged, albeit not detailed, by legislation.

- Is it possible to perform energy efficiency assessment in a simplified, yet accurate way?

- One of the most complicated calculations is that of solar heat contribution.

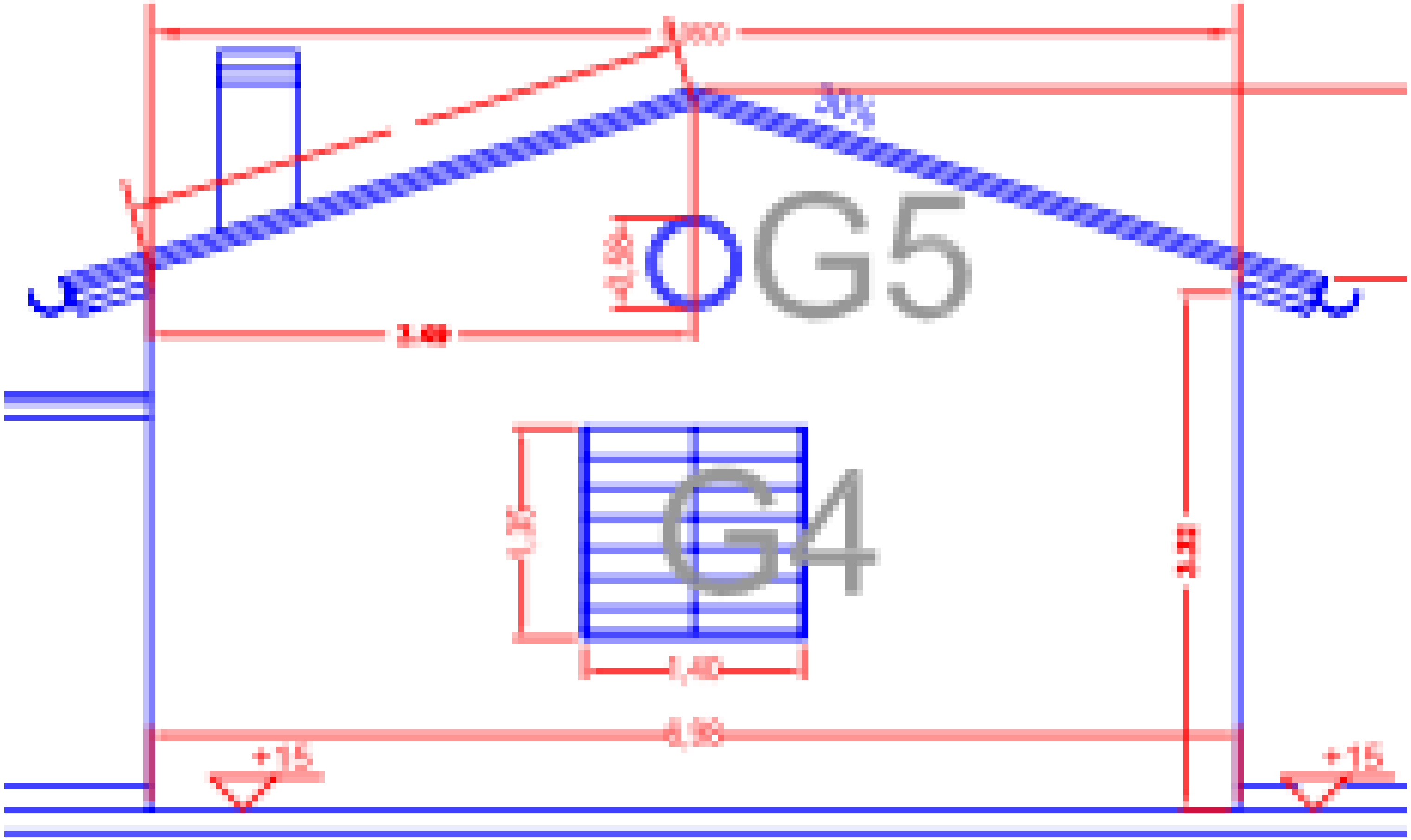
- for each month and for each exposure direction, the time percentage during which shutters are kept closed needs to be taken into account.

- A possible simplification (which does not involve any loss of accuracy) consists in conservatively assume for all month the "closed" time percentage of the worst month.

- This way, only four figures need be taken into account, instead of 28-30.

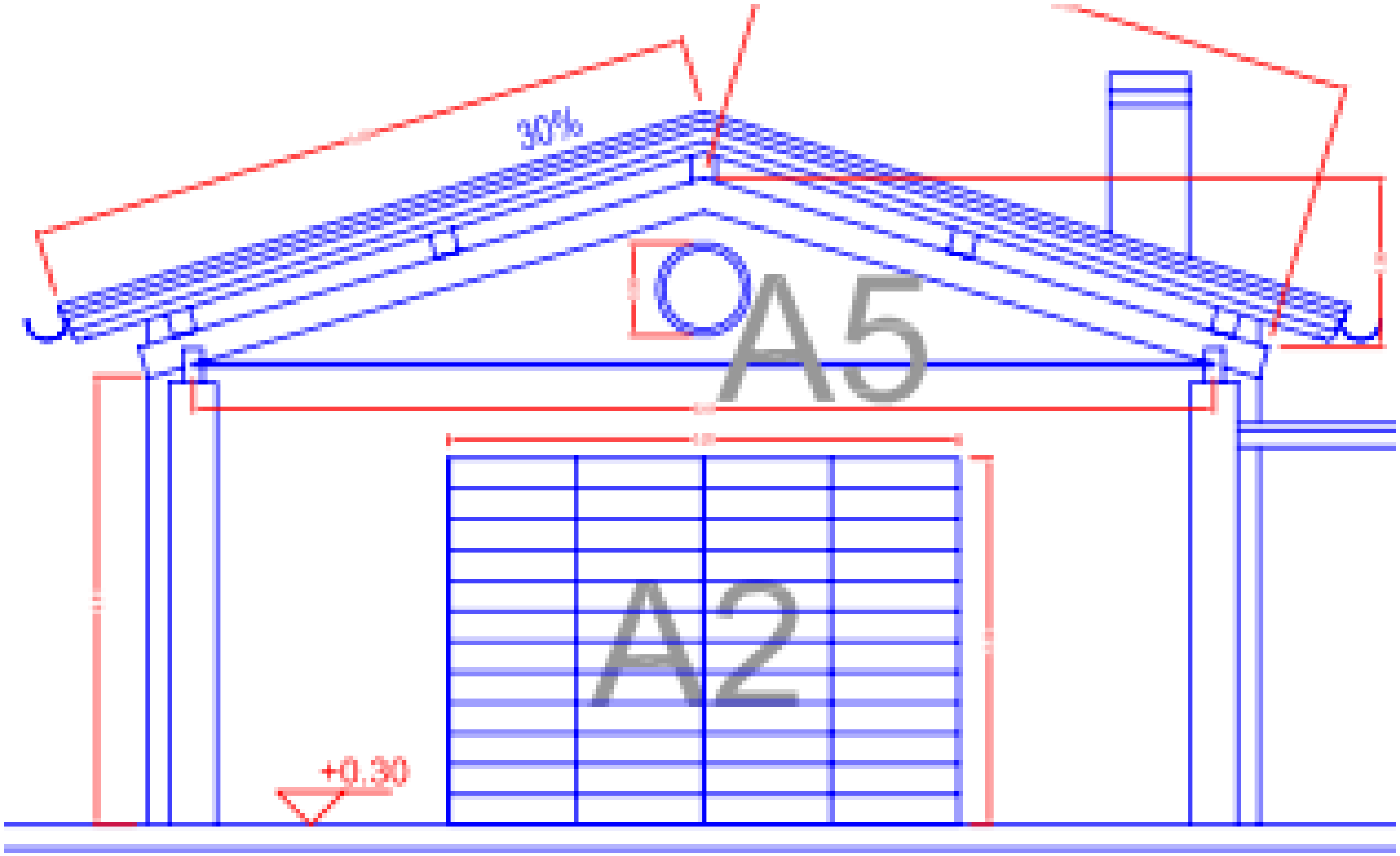
- We have selected a stand-alone, 2011 designed house in central Italy.

- The house is thermally isolated and equipped with heating (but no cooling) installation.

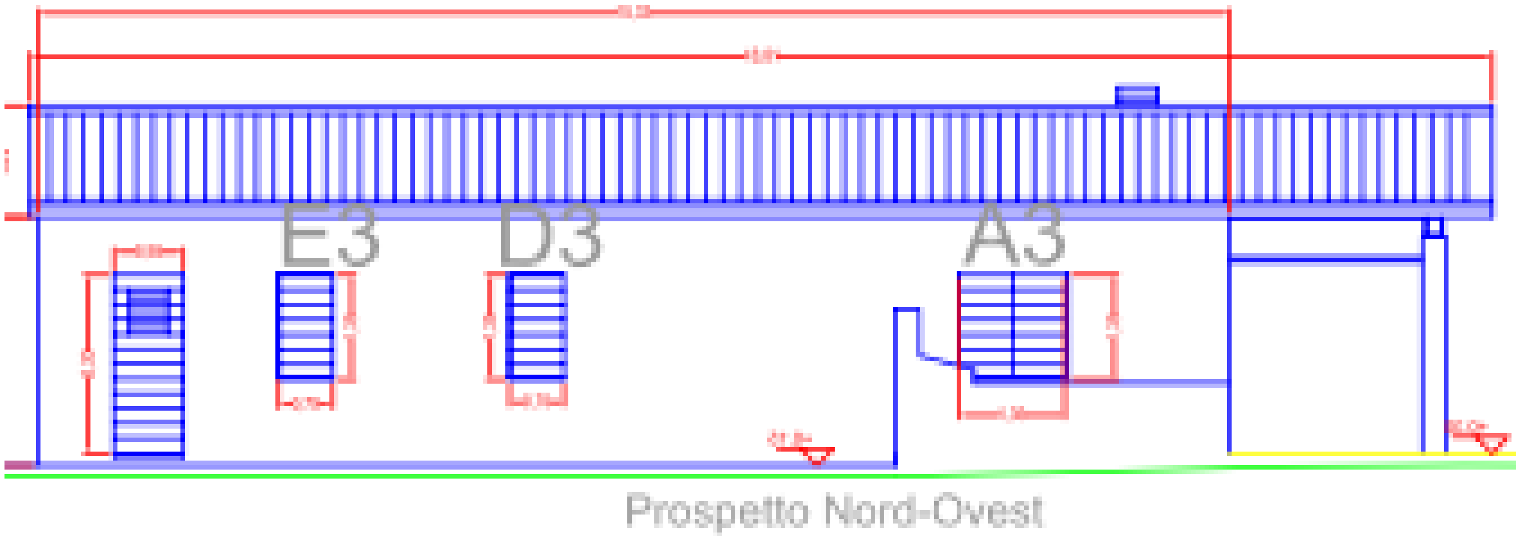


Prospetto Nord-Est

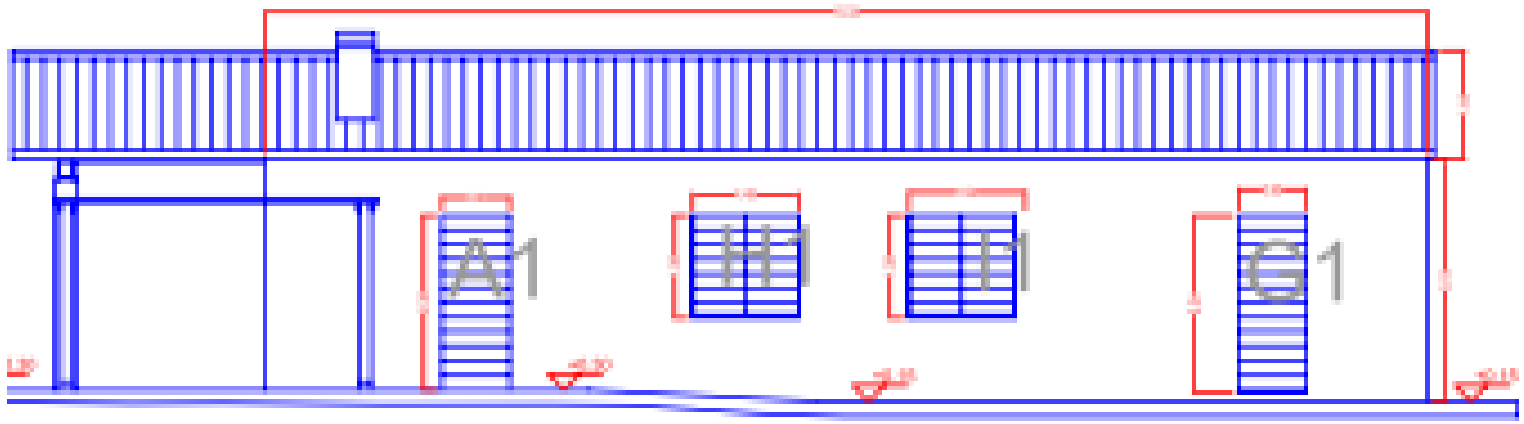
ITALIA CENTRALE: ABITAZIONE ISOLATA



ITALIA CENTRALE: ABITAZIONE ISOLATA

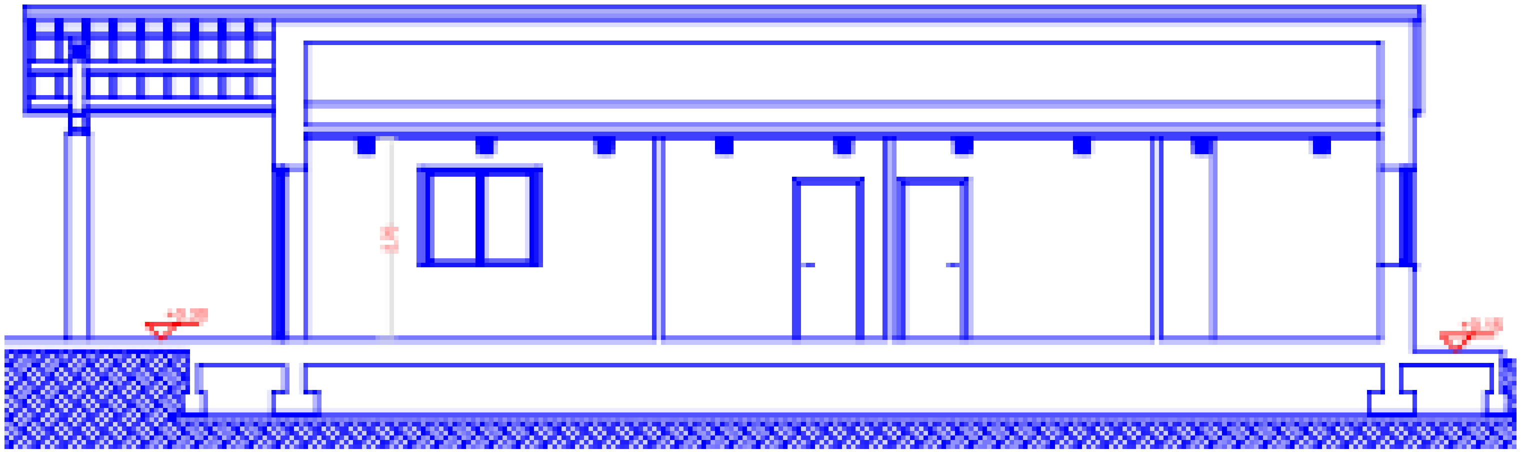


ITALIA CENTRALE: ABITAZIONE ISOLATA

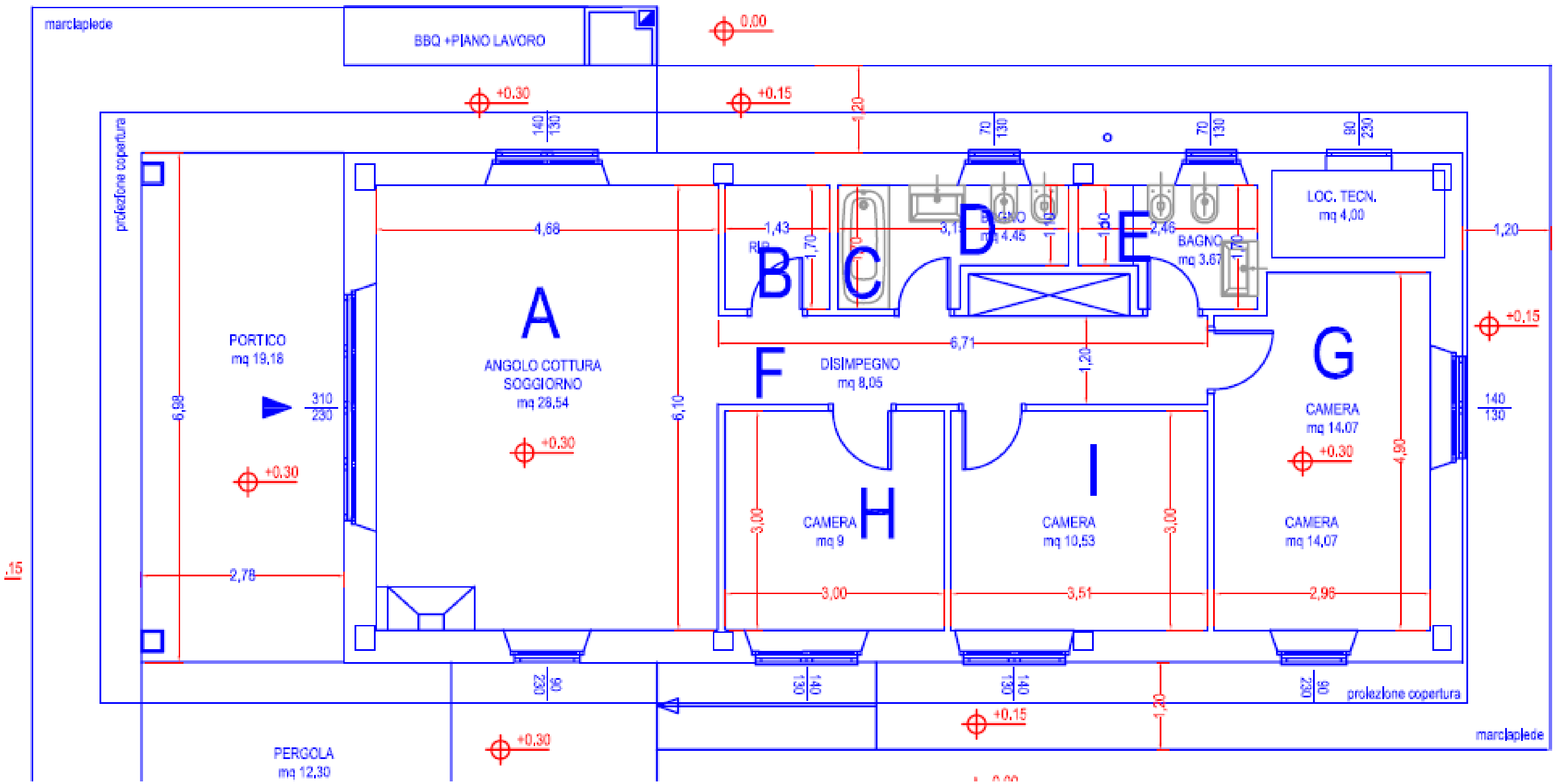


Prospetto Sud Est

ITALIA CENTRALE: ABITAZIONE ISOLATA



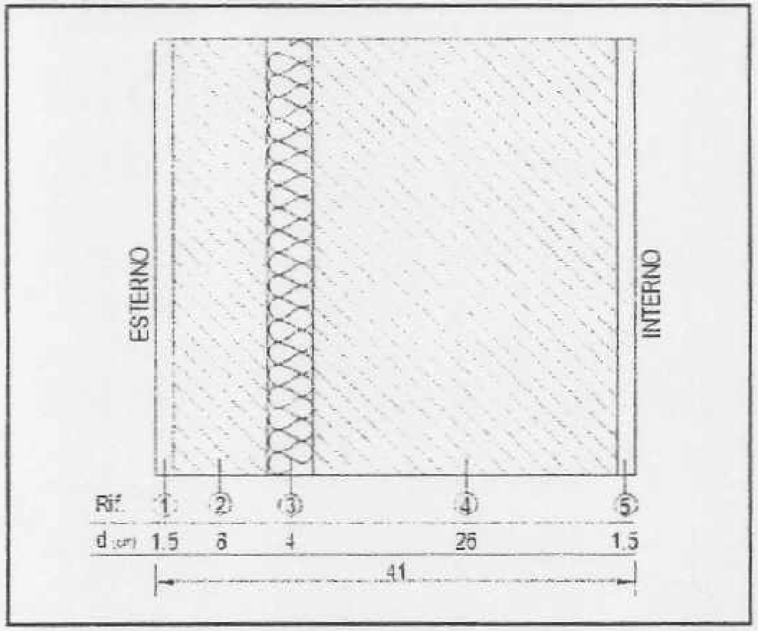
ITALIA CENTRALE: ABITAZIONE ISOLATA



CARATTERISTICHE TERMICHE E GEOMETRICHE DELLA PARETE

rif.		elemento costruttivo	d [m]	ρ [Kg/m³]	c [J/kgK]	λ [W/mK]	R [m²/WK]	δ [m]	ξ [/]	μ [/]	S_d [m]
1		intonaco esterno	0,015	1500	1000	0,550	0,03	0,100	0,149	10	0,15
2	NT 38	muratura TVI 202C (1)	0,080	871	1000	0,209	0,38	0,081	0,985	10	0,80
3	NT 38	lastra in EPS	0,040	30	1450	0,035	1,14	0,149	0,269	60	2,40
4	NT 38	muratura TV 2204V (2)	0,260	705	1000	0,140	1,85	0,074	3,513	16	4,16
5		intonaco interno	0,015	1500	1000	0,550	0,03	0,100	0,149	20	0,30
		d_{tot}	0,410			R_{tot}	3,43				

Stratigrafia



- We have first assessed the EPi (Energy Performance index for heating) rigorously; namely, we have distinguished the various months that make up the heating season.

CASO STUDIO: VILLETTA ISOLATA
Bilancio termico per riscaldamento

06/03/2017	Qhtr (kWh)	Qhpt (kWh)	F x Fl x t (kWh)	Qhve (kWh)	Eta	Qint (kWh)	Qsol (kWh)	Qh(kWh)
	a	b	c	d	e	f	g	h=(a+b+c+d)-e*(f+g)
GENNAIO	1.274,59	98,55	46,14	563,35	1,00	334,71	356,68	1.291,25
FEBBRAIO	1.037,86	80,25	41,68	458,72	1,00	302,32	369,58	946,64
MARZO	936,63	72,42	46,14	413,98	1,00	334,71	497,61	638,03
APRILE	317,71	24,57	22,33	140,42	0,90	161,96	313,67	75,97
MAGGIO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
GIUGNO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
LUGLIO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AGOSTO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SETTEMBRE	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
OTTOBRE	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
NOVEMBRE	775,60	59,97	44,65	342,80	1,00	323,91	379,02	521,31
DICEMBRE	1.149,06	88,84	46,14	507,87	1,00	334,71	289,88	1.167,33
							TOT	4.640,53

Primary energy: yearly demand for heating

$$\frac{4640{,}53}{0{,}76} = 6080{,}56 \text{ kWh/anno}$$

Primary energy: heating demand per year and per square meter

$$\frac{6080,56}{105,78} = 57,48 \text{ kWh/m}^2 \text{ anno}$$

Overall Energy Performance Index, EPgl: sum of

- *Epi (heating)*
- *Epacs (Domestic Hot Water).*

57,48+20,67=78,15 kWh per square meter and per year

- As per applicable legislation, we then performed the calculation, in the same condition, for the “reference building”.

ALLEGATO 1

LINEE GUIDA NAZIONALI
PER L'ATTESTAZIONE DELLA PRESTAZIONE ENERGETICA
DEGLI EDIFICI

Tabella 2 - Scala di classificazione degli edifici sulla base dell'indice di prestazione energetica globale nc
rinnovabile $EP_{gl,nren}$

	Classe A4	$\leq 0{,}40\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}40\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A3**	$\leq 0{,}60\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}60\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A2**	$\leq 0{,}80\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}80\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A1**	$\leq 1{,}00\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}00\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe B**	$\leq 1{,}20\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}20\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe C**	$\leq 1{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}50\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe D**	$\leq 2{,}00\ EP_{gl,nren,rif,standard\ (2019/21)}$
$2{,}00\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe E**	$\leq 2{,}60\ EP_{gl,nren,rif,standard\ (2019/21)}$
$2{,}60\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe F**	$\leq 3{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$
	Classe G	$> 3{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$

Classe A4

- Valore minimo: 0
- Valore massimo: $0{,}4 \bullet 72{,}39 = 28{,}95$

Classe A3

- Valore minimo: $0{,}4 \bullet 72{,}39 = 28{,}95$
- Valore massimo: $0{,}6 \bullet 72{,}39 = 43{,}43$

Classe A2

- Valore minimo: $0{,}6 \bullet 72{,}39 = 43{,}43$
- Valore massimo: $0{,}8 \bullet 72{,}39 = 57{,}91$

Classe A1

- Valore minimo: $0{,}8 \bullet 72{,}39 = 57{,}91$
- Valore massimo: $1 \bullet 72{,}39 = 72{,}39$

Classe B

- Valore minimo: $1 \bullet 72{,}39 = 72{,}39$
- Valore massimo: $1{,}2 \bullet 72{,}39 = 86{,}86$

Classe C

- Valore minimo: $1{,}2 \bullet 72{,}39 = 86{,}86$
- Valore massimo: $1{,}5 \bullet 72{,}39 = 108{,}58$

Classe D

- Valore minimo: $1{,}5 \bullet 72{,}39 = 108{,}58$
- Valore massimo: $2 \bullet 72{,}39 = 144{,}77$

Classe E

- Valore minimo: $2 \bullet 72{,}39 = 144{,}77$
- Valore massimo: $2{,}6 \bullet 72{,}39 = 188{,}20$

Classe F

- Valore minimo: $2,6 \bullet 72,39 = 188,20$
- Valore massimo: $3,5 \bullet 72,39 = 253,35$

Classe G

- Valore minimo: $3,5 \bullet 72,39 = 253,35$
- Valore massimo: n.a.

Indice di prestazione globale:
78,15 kWh per metro quadrato e per anno

Classe di prestazione: B

- After that, we repeated the whole procedure with the conservative hypothesis described above (solar heat contribution underestimated).

- The calculation was much simpler and rapid.

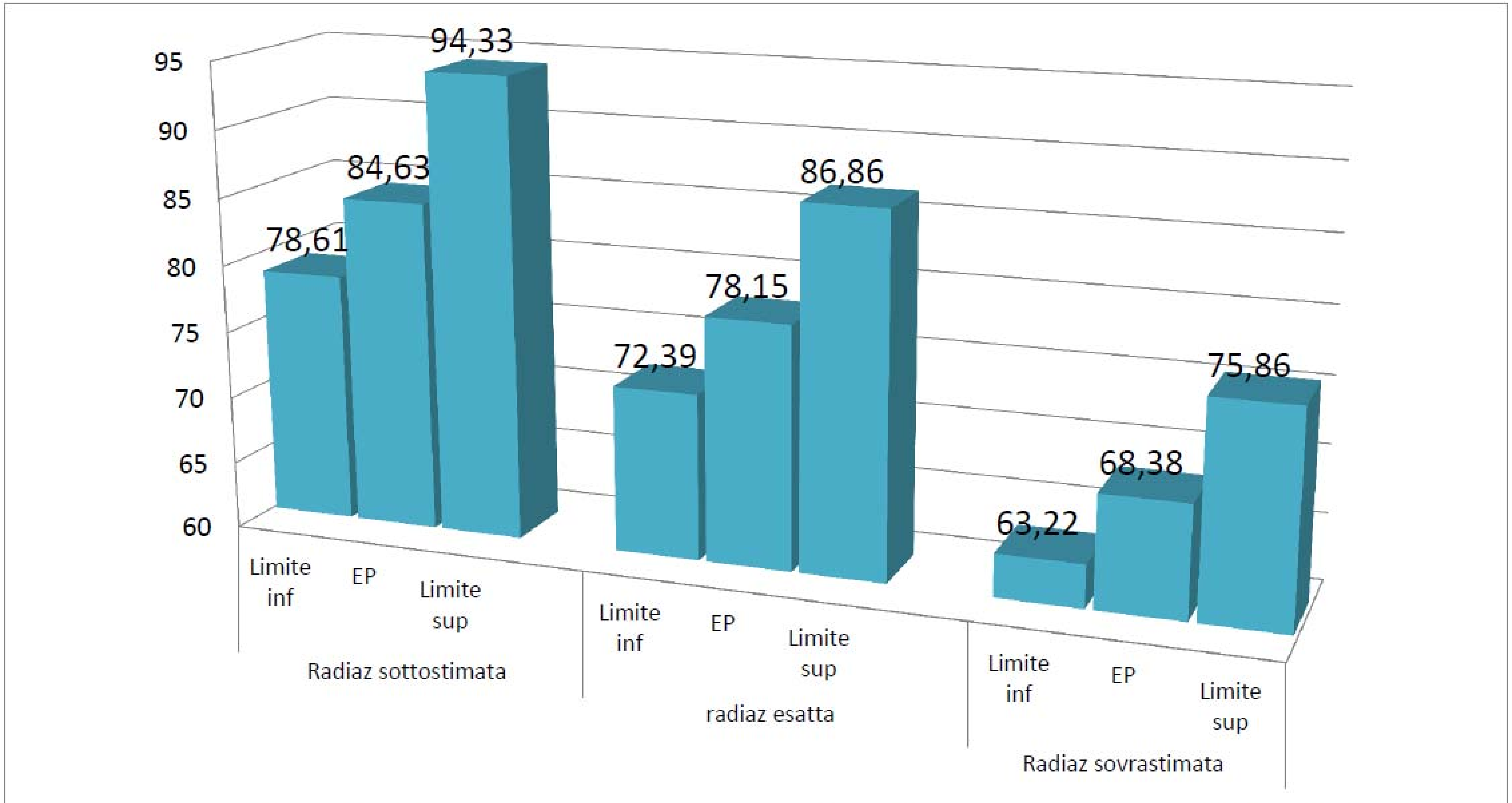
- Both EPi’s (real building’s and reference building’s) turned out to be higher (worse) than respective “rigorous” values.

- In order to test the method once more, we performed a further calculation, based, this time, on an overestimate of solar heat contribution.

- Not surprisingly, EPi’s turned out to be better (lower) than corresponding rigorous values.

- In all cases
  - rigorous calculation;
  - solar heat underestimated;
  - solar heat overestimated)

- the energy efficiency class of the house turned out to be the same (namely, a B class).



	Radiaz sottostimata				radiaz esatta				Radiaz sovrastimata		
	Limite inf	EP	Limite sup		Limite inf	EP	Limite sup		Limite inf	EP	Limite sup
Classe B	78,61	84,63	94,33		72,39	78,15	86,86		63,22	68,38	75,86

Conclusions

- Energy classification of buildings is largely independent of solar heat contribution. This is because solar heat acts “in the same direction” on both EPi’s.

- Underestimating solar heat results in an overestimate of EPi, both for the real building and for the reference building.

Conclusions

- EPi for reference building also affects the upper and lower limits of ranges associated with energy classes.

- These limits, which are proportional to EPi of the reference building, are themselves overestimated.

Conclusions

- Error is small: conservative EP exceeds «true» EP by just 9%.
- It should also be kept in mind that this specific building is far from any other: the sun is only shielded by the shutters.
- Usually, however, other shields are present: surrounding buildings, trees, hills, balconies etc.
- All the above provide further shielding to the the sun, which makes the conservative assumption even more realistic.

Conclusions

- Besides: is it really possible to know how long the shutters will be kept closed each month? UNI/TS11300 provides a merely probabilistic, largely uncertain guess.
- For all these reasons, a typical value of 4-5% can be assumed for the uncertainty due to the overestimate of EP.
- Such an uncertainty is very close to, or even smaller than, that regarded as acceptable by legislation about software («decreto ministeriale 26 giugno 2015», art. 7, comma 1).

Conclusions

- Conservatively underestimating solar heat is an efficient way to simplify calculation.
- No loss of accuracy: the energy class of the building is unchanged.
- If such an approximation were to be adopted in software tools, a significant cost reduction might be expected.

Thank you for your attention

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