CONFERENZA FINALE

Bolzano, KLIMAHOUSE – Sala Ceredale, 24 gennaio 2019

"Tegole innovative per il risparmio energetico e il comfort estivo"

SENSAPIRO, il software per il calcolo delle prestazioni del tetto ventilato

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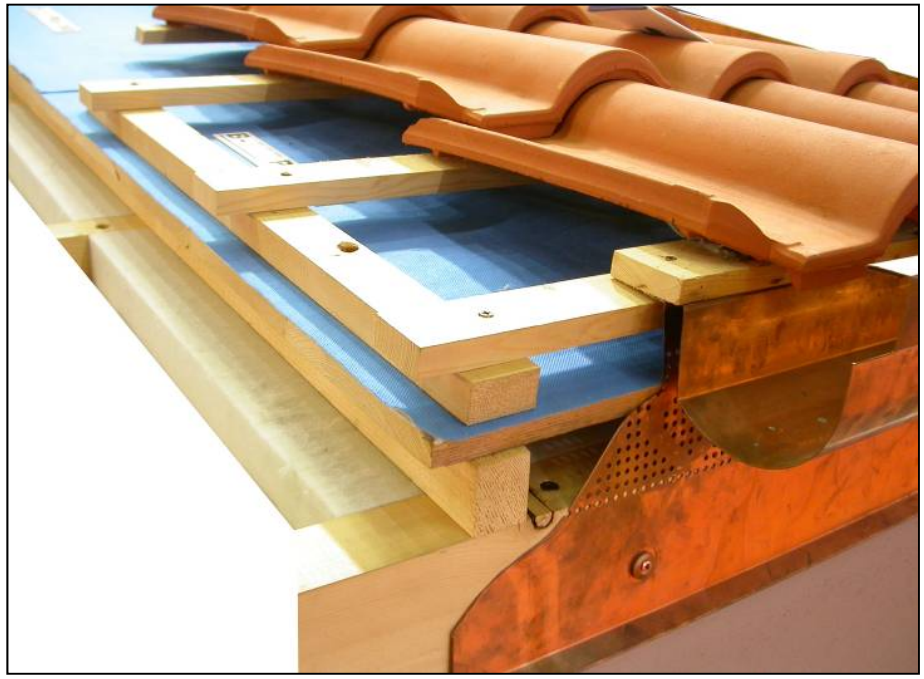
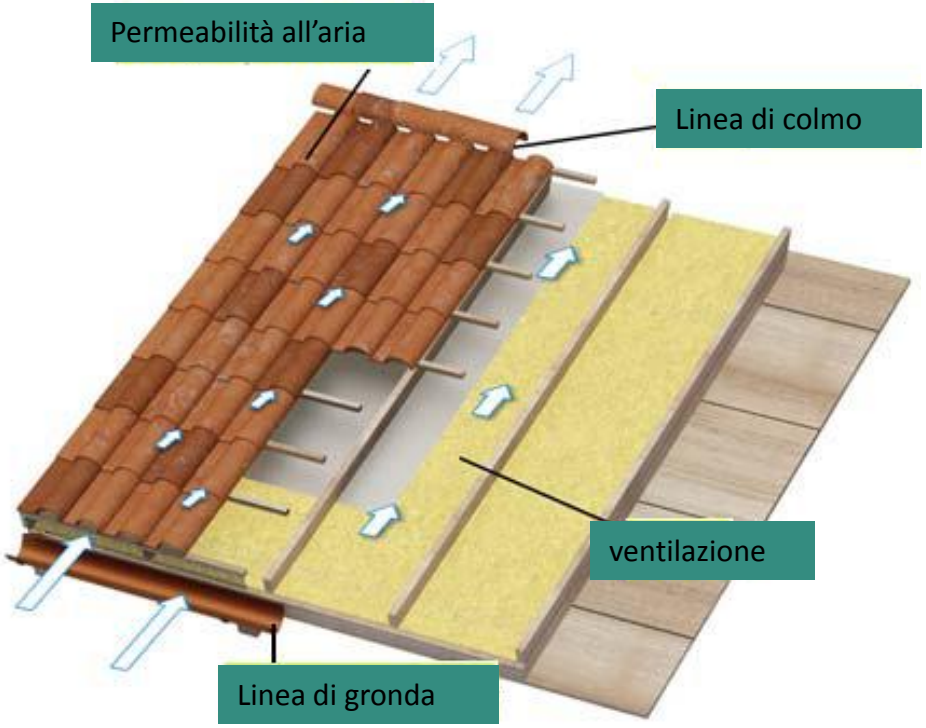
HIGH ENERGY SAVINGS IN BUILDING COOLING BY ROOF TILES SHAPE OPTIMIZATION TOWARD A BETTER ABOVE SHEATHING VENTILATION

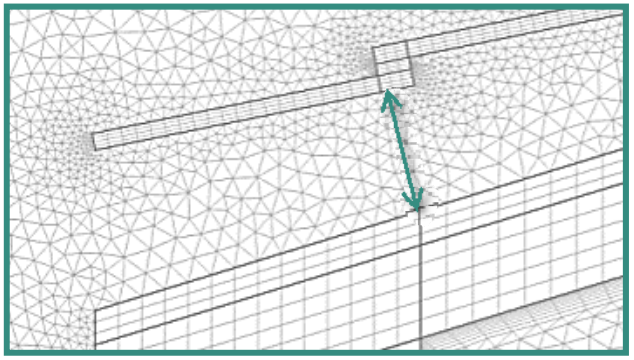
lifeHEROTILE

Nei tetti ventilati l'aria entra dalla linea di **gronda** ed esce dalla linea di **colmo**.
Aumentare la permeabilità all'aria fra le tegole migliora questa prestazione.

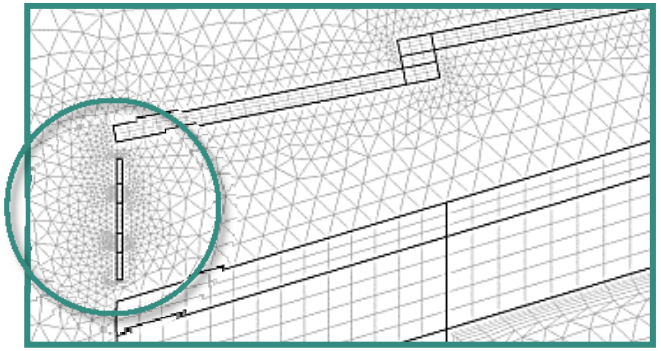




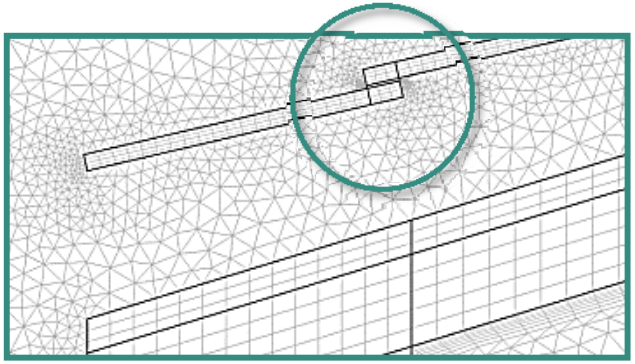
modifiche



Strato di ventilazione 4/8 cm

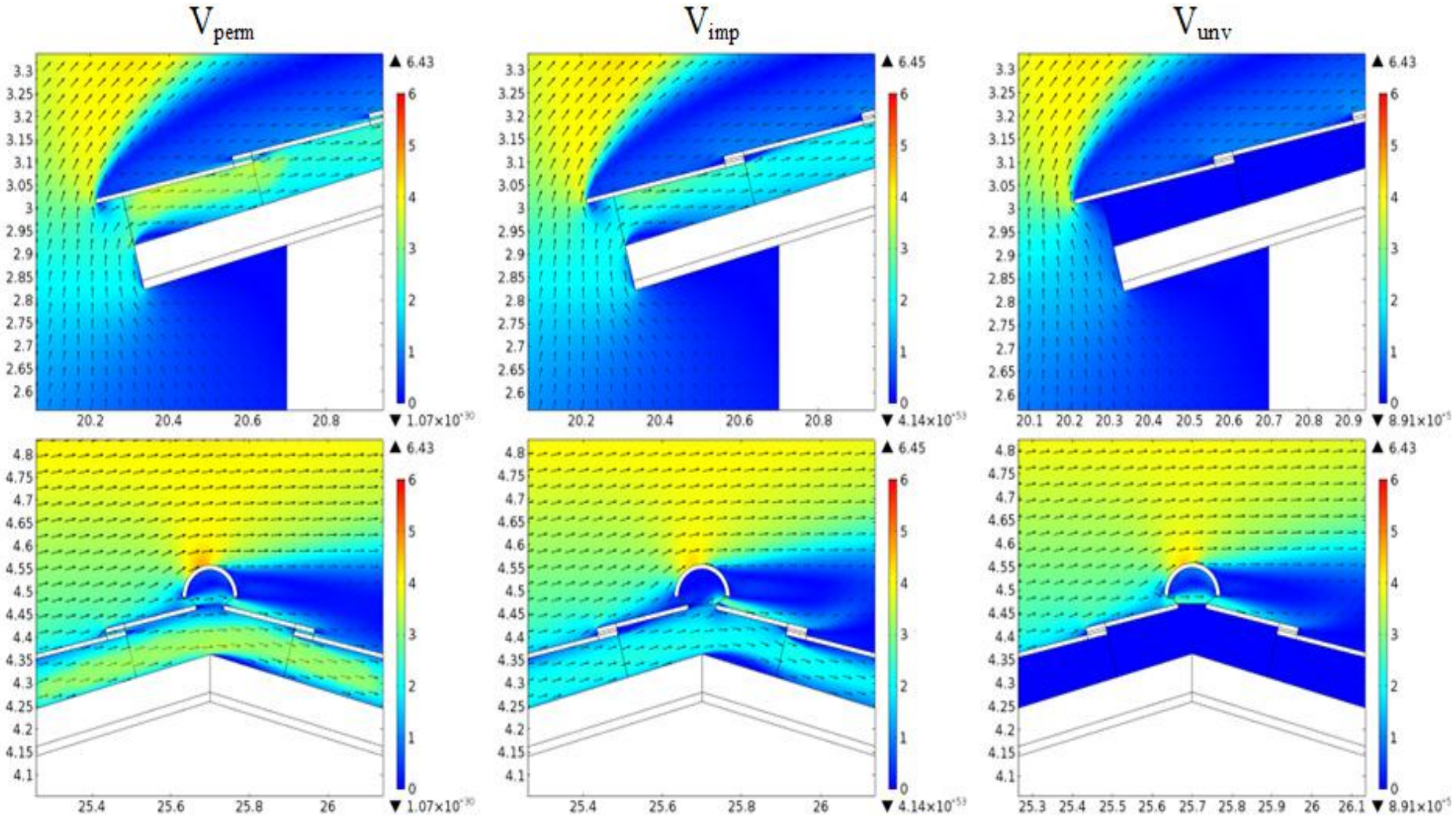


Apertura in gronda 0-50-100%



Permeabilità all'aria 0.0/2.5/9.0 mm

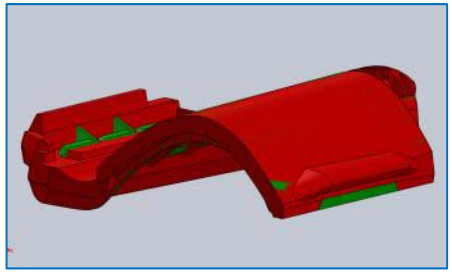
Tetto ventilato

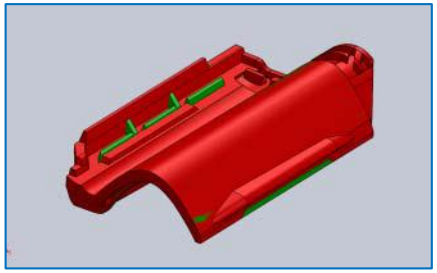


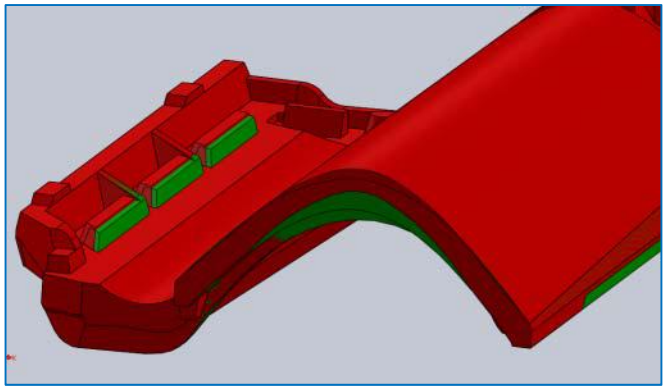
Obiettivo del progetto HEROTile è stato:

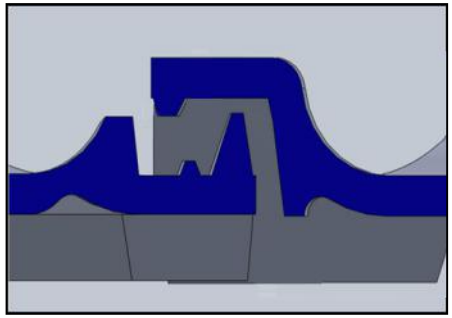
- Riprogettare il design delle tegole
- Confrontarne le prestazioni con le tegole standard
- Verificare le prestazioni con test al vero

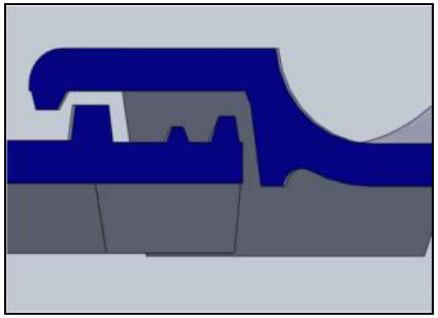
24 soluzioni progettate e testate di tegola portoghese e marsigliese

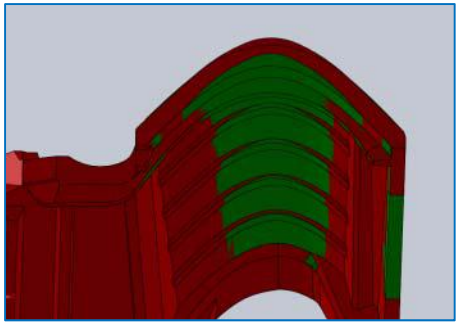










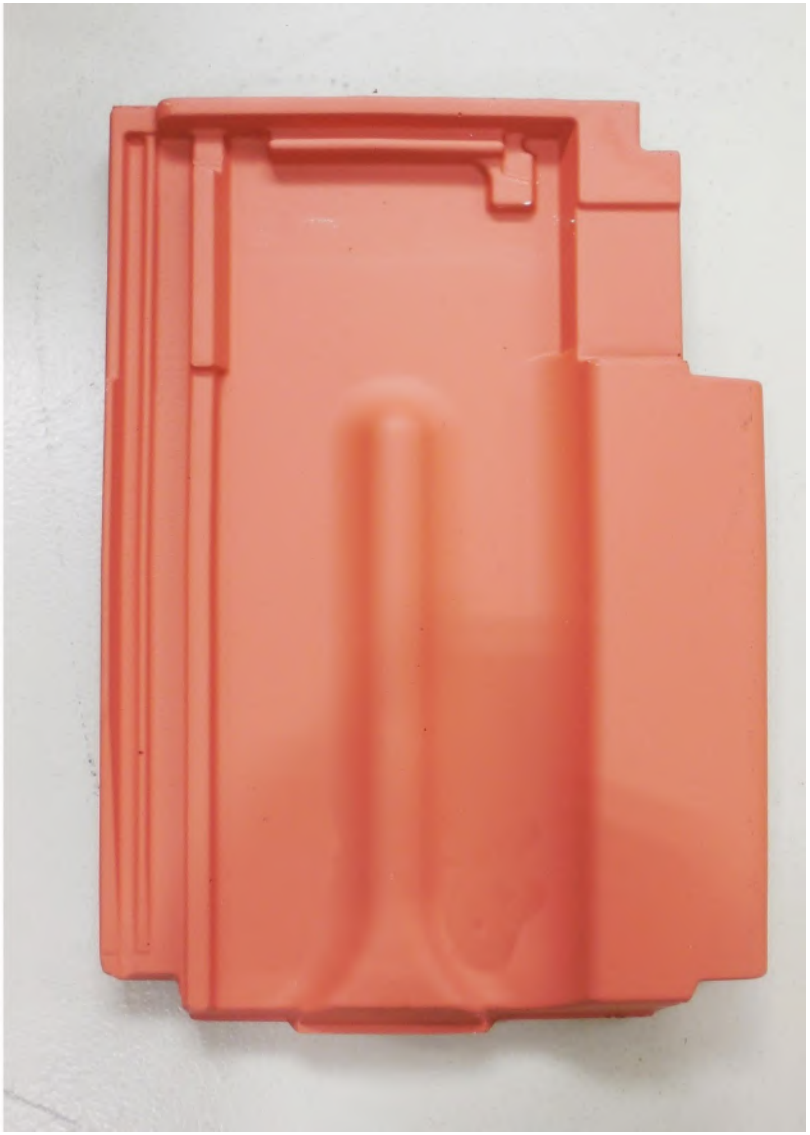


Matrice di valutazione

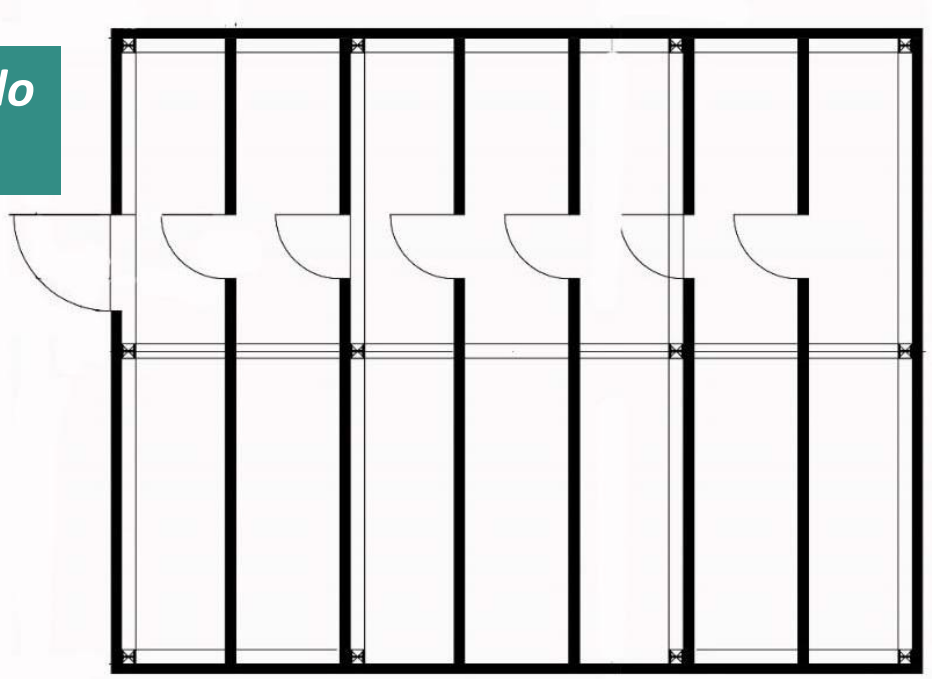
Parameter	Case_01n	Case_02n	Case_03n	Case_04n	Case_05n	Case_06m	Case_07m	Case_08mb	Case_09m	Case_10m
Air permeability	**1.77**	**2.17**	**1.51**	**1.92**	**1.73**	**1.36**	**1.33**	**1.58**	**1.81**	**1.31**
Waterproof	-1.00	-0.36	-0.07	0.14	-0.54	-0.54	-0.79	-1.00	-1.00	-0.79
Conformity of standard regulation	0.00	0.00	-0.21	-0.48	-0.48	0.00	-0.48	0.00	0.00	0.00
Aesthetic index	0.00	-0.48	-0.33	-0.15	-1.00	-0.33	-0.33	0.00	-0.37	0.33
Line production cost	-0.46	-0.64	-0.64	-1.00	-1.00	0.00	-0.46	0.00	0.00	0.00
Unitary cost	-0.13	-0.13	-0.35	-0.35	-1.00	0.00	-0.13	0.00	0.00	0.00
Mechanical performance	-0.44	-0.44	-0.44	-0.44	-1.00	0.00	-0.20	0.00	0.00	0.00
Installation cost	-0.23	-0.23	-0.46	-0.46	-0.77	0.00	-0.54	0.00	-0.23	0.00
Commercial index	0.00	0.29	0.21	0.46	-0.82	-0.07	0.11	0.21	-0.25	0.46
	0.28	0.57	0.17	0.30	-2.24	0.56	-0.32	0.49	0.37	0.48

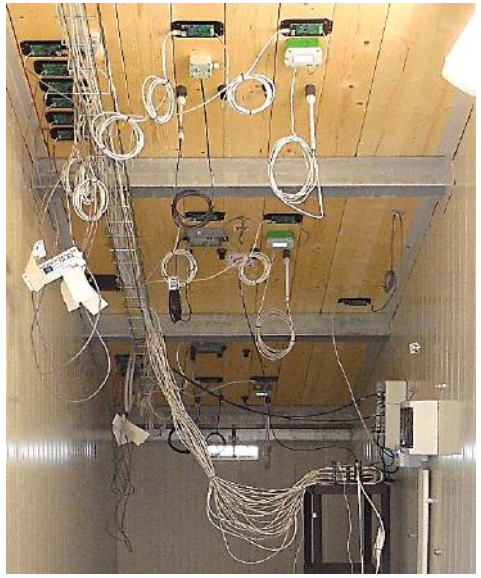
Test in galleria del vento e messa in produzione

portoghese Herotile *marsigliese Herotile*



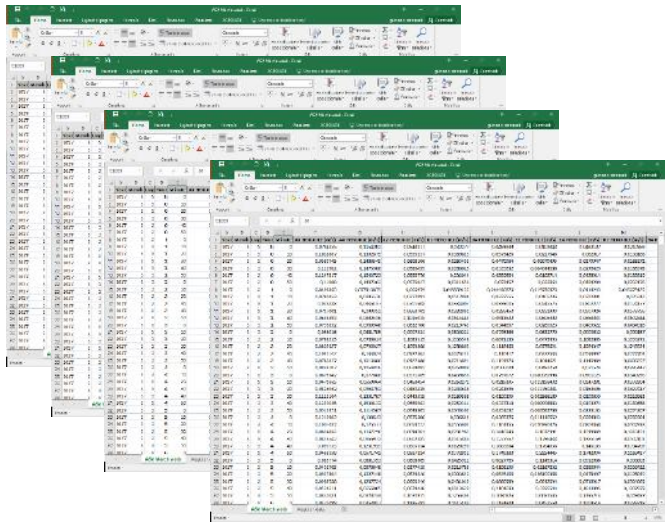
Università di Ferrara, Tecnopolo
CAI Factory, Yeruham (Israele)



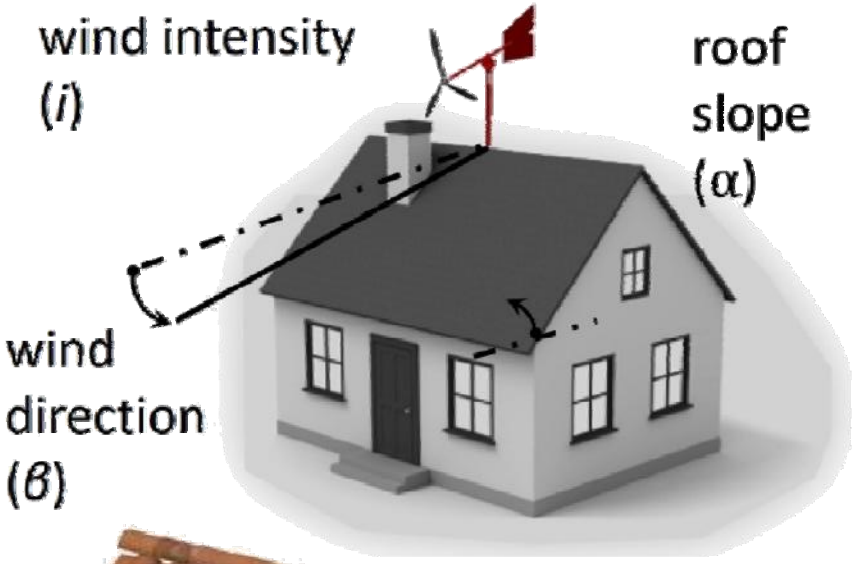


Sperimentazione al vero

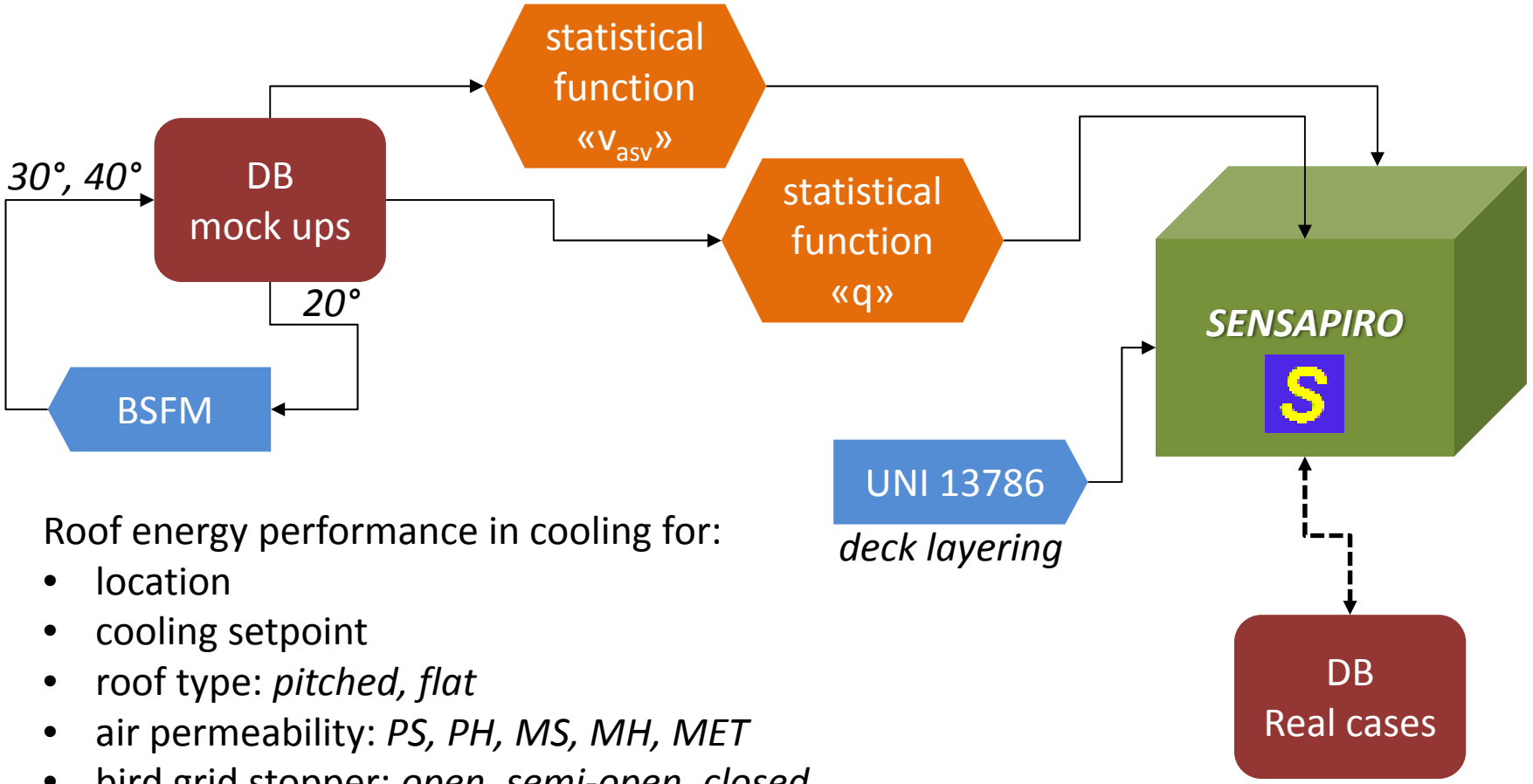
Reggio Emilia (Italia)
Saragozza (Spagna)



Come risolvere il problema



Metodologia

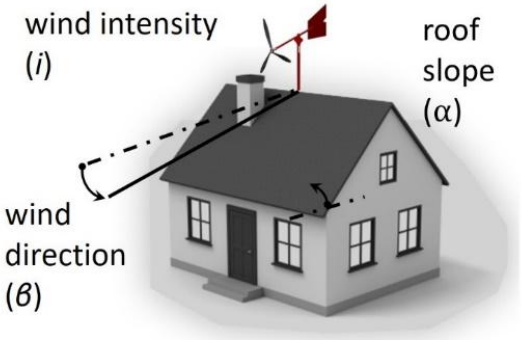


Roof energy performance in cooling for:

- location
- cooling setpoint
- roof type: *pitched, flat*
- air permeability: *PS, PH, MS, MH, MET*
- bird grid stopper: *open, semi-open, closed*
- roof thermal insulation

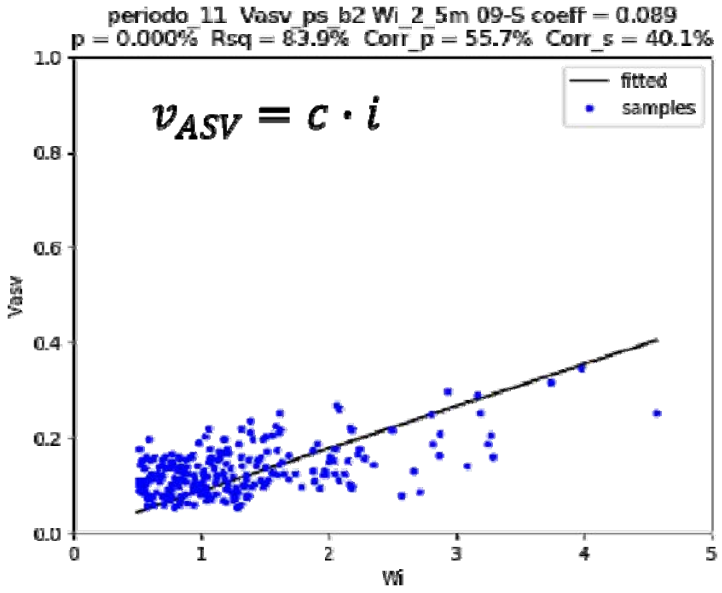
Ventilazione sottomanto

$$v_{ASV} = F(i)$$

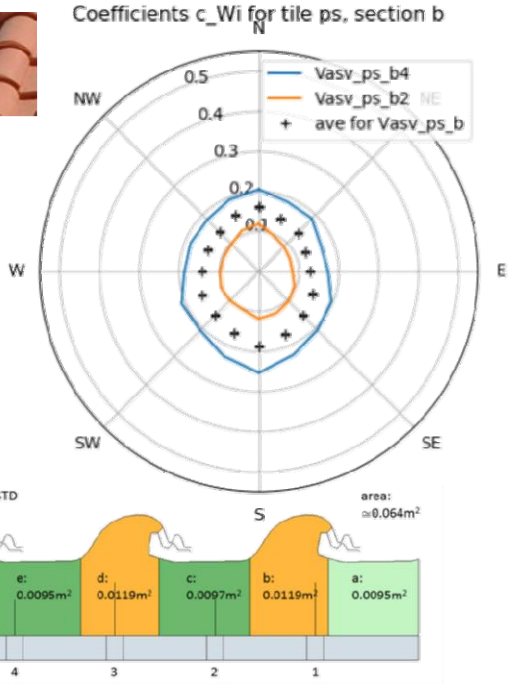


the function “F” changes according:

- roof type (PS,PH,MS,MH,MET)
- stopping bird (closed, 50% or 100% open)
- wind direction (16)
- pitch slope (20, *30** and *40** deg)



DATASET of 720 values (file coeff_polar_ASV)



Apporto termico

$$q = a_0 + a_1 Z_{irr} + a_2 GH + a_3 V_{ASV} + a_4 V_w$$

- q: heat gain [Wh m^{-2} day^{-1}]
- $a_1 Z_{irr}$: solar gain
- $a_2 GH$: degree hours
- $a_3 V_{ASV}$: ASV impact
- $a_4 V_w$: wind run

V_{ASV} is calculated from the previous former relationship
Z_{irr} , GH and V_w follow weather data and air conditioning setpoint

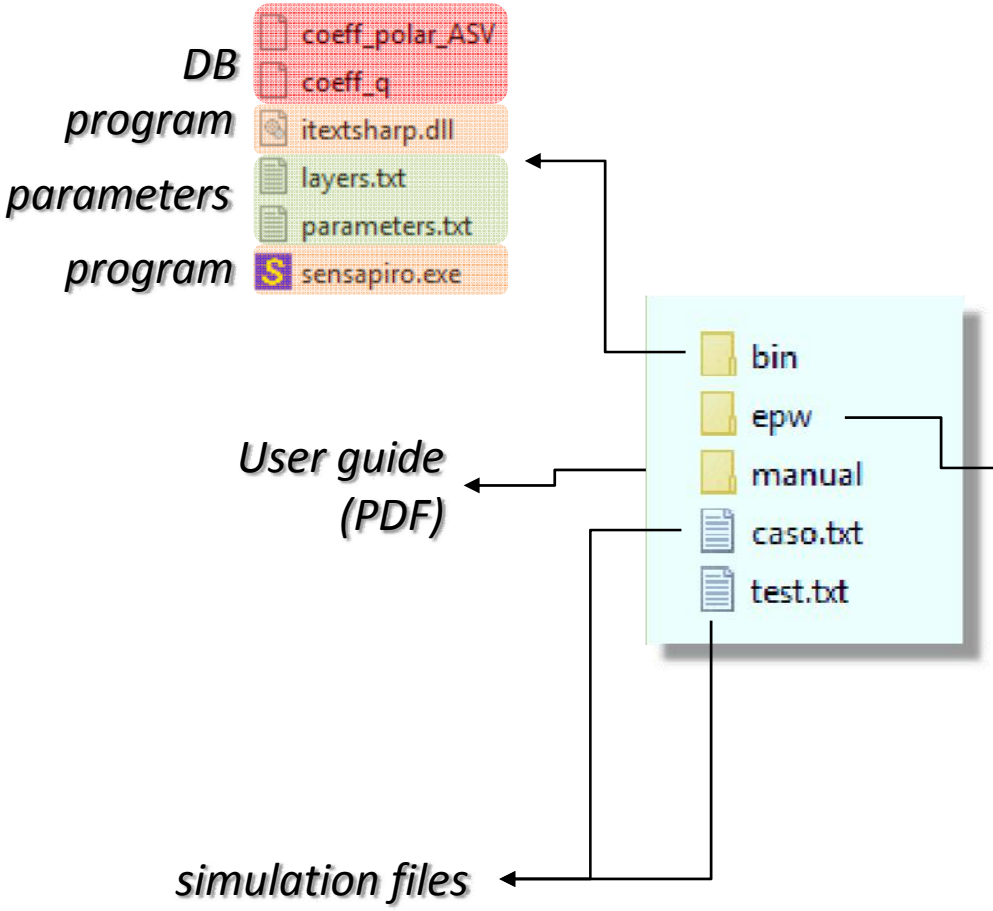
Parameters from a_0 to a_4 change according to:

- roof types (P_{std} ,P_{hero} ,M_{std} ,M_{hero} ,MET ,$FLAT$)
- roof orientation (16 sectors)
- roof pitch (*20°, 30°, 40°*)
- eave types (*closed, semi-open, open*)

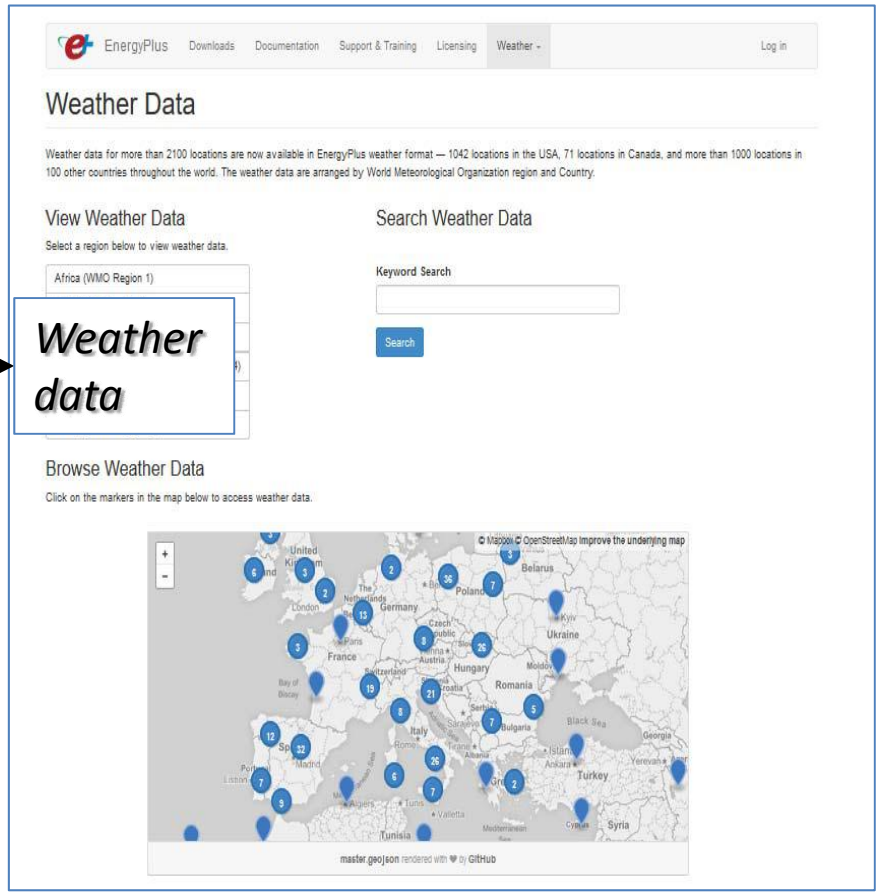
DATASET of 864 values (file coeff_q)

Intermediate parameters are linearly interpolated

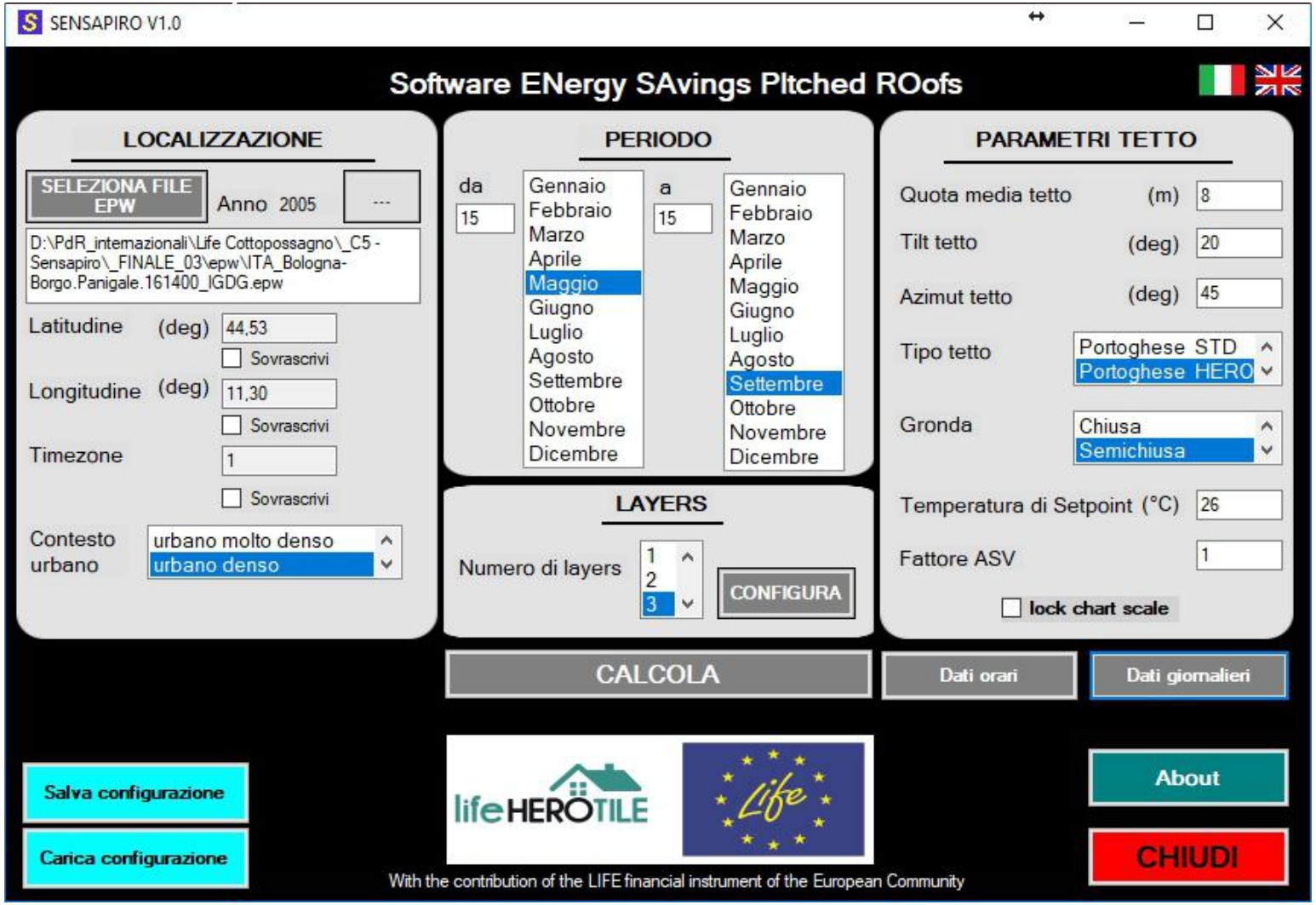
SENSAPIRO



https://energyplus.net/weather



Schermata iniziale

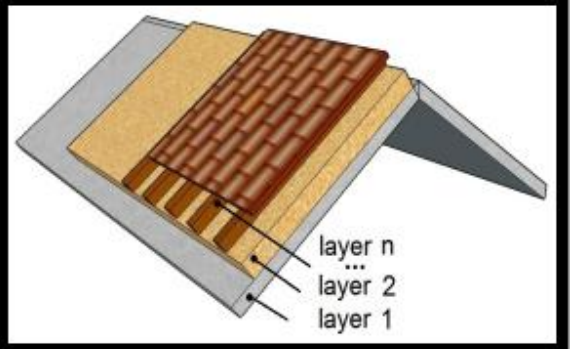


UNI EN ISO 13786:2018 *Thermal performance of building components - Dynamic thermal characteristics - Calculation methods*

Layers

LAYERS

Layer 1 to Layer n		Thickness (mm)	Thermal conductivity (W/mK)	Density (kg/m3)	Specific heat capacity (J/kgK)
L1	Intonaco calce cemento	20	0,9	1800	1000
L2	Solaio in laterocemento (20+6)	260	0,74	1150	1000
L3	XPS	60	0,032	35	1450
L4	Membrana in PVC	5	0,15	1200	900



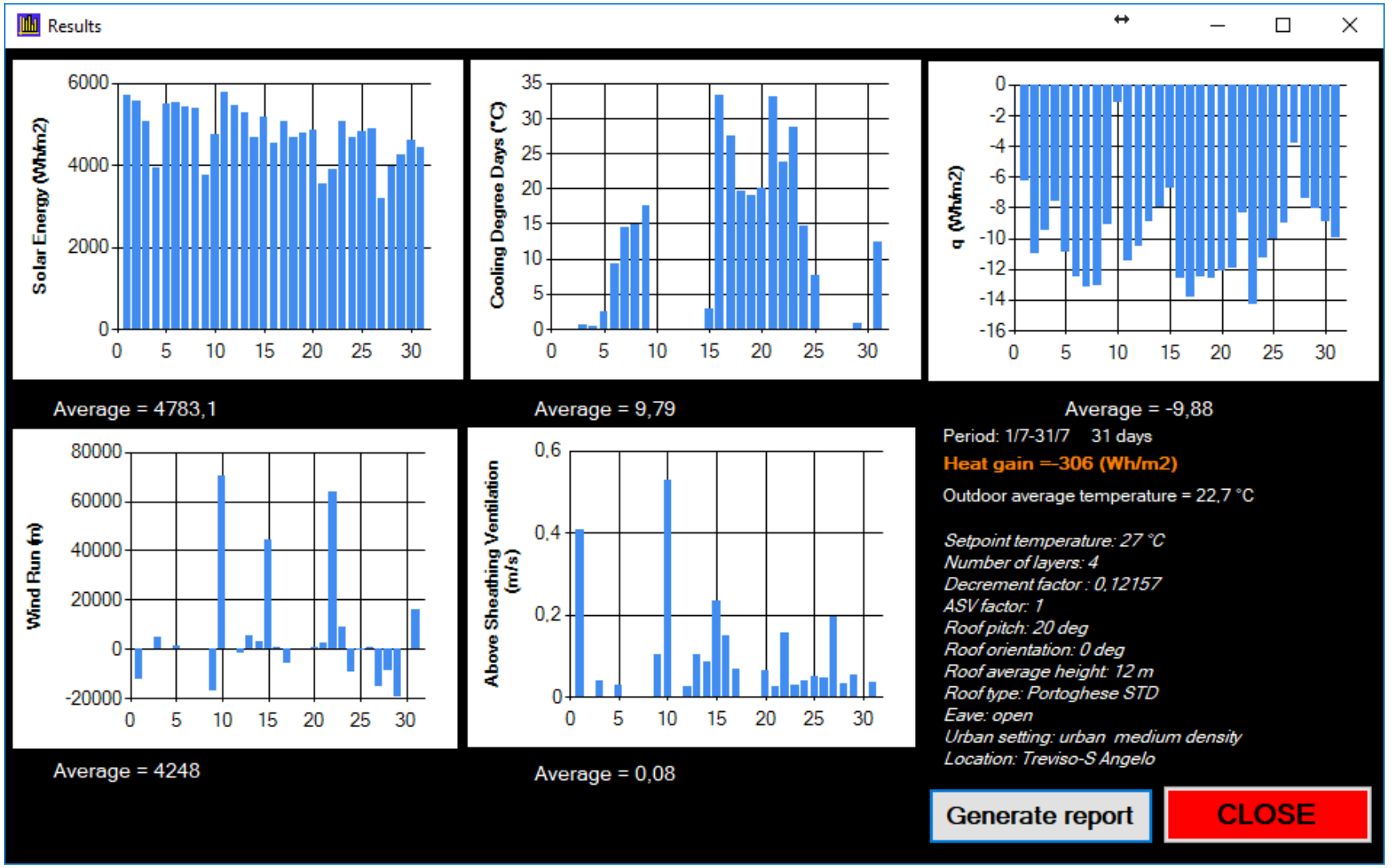
Calculate

0,15284

CLOSE

Decrement factor = 0,15284
Thermal transmittance phase shift = 9,979 (h)
Periodic thermal transmittance = 0,062 (W/m2 K)
Internal thermal admittance = 4,511 (W/m2 K)
External thermal admittance = 0,687 (W/m2 K)
Component thermal resistance = 2,282 (m2 K/W)
System thermal resistance = 2,452 (m2 K/W)

Risultati *(1/3)*



Risultati (2/3)

***G0*, l'irraggiamento solare caricato dal file EPW [W m^{-2}];**
***T dry bulb*, la temperatura di bulbo secco caricata dal file EPW [°C];**
***W$_i$*, la velocità del vento caricato dal file EPW [m s^{-1}];**
***W$_d$*, la direzione del vento caricato dal file EPW [deg];**
***W$_i$ new*, la componente del vento incidente normalmente al tetto [m s^{-1}].**

Dati orari

Data e ora	G0	T dry bulb	Wi	Wi new	Wd
gg/mm/aaaa hh:mm	W/m2	°C	m/s	m/s	deg
01/01/2005 00:00	0	1	0	0	218
01/01/2005 01:00	0	0,4	0	0	203
01/01/2005 02:00	0	-0,6	0,8	0,732	59
01/01/2005 03:00	0	-1,8	0,8	0,732	50
01/01/2005 04:00	0	-2	0,8	0,732	276
01/01/2005 05:00	0	-1,8	1,6	1,463	46
01/01/2005 06:00	0	-1,2	1,6	1,463	252
01/01/2005 07:00	0	-0,6	1,6	1,463	28
01/01/2005 08:00	36	0,2	1,6	1,463	339
01/01/2005 09:00	100	1,2	0,8	0,732	155
01/01/2005 10:00	156	2,5	0,8	0,732	274
01/01/2005 11:00	193	4	0	0	78
01/01/2005 12:00	200	5,8	0	0	84
01/01/2005 13:00	176	6,7	0	0	335
01/01/2005 14:00	129	7,2	0	0	96
01/01/2005 15:00	71	7,4	0	0	66
01/01/2005 16:00	13	7,1	0	0	313
01/01/2005 17:00	0	6,5	0	0	91
01/01/2005 18:00	0	5,4	0	0	46
01/01/2005 19:00	0	5,1	0	0	134
01/01/2005 20:00	0	5	0	0	30
01/01/2005 21:00	0	5	0	0	113
01/01/2005 22:00	0	4,9	0	0	352
01/01/2005 23:00	0	4,7	0	0	202
02/01/2005 00:00	0	4,6	0	0	105
02/01/2005 01:00	0	4,5	0	0	241
02/01/2005 02:00	0	4,4	0	0	213

Esporta dati
CLOSE

Dati giornalieri

Giorno	GH	Vw	Z irr	Vasv	q
gg/mm	°C	m	Wh/m2	m/s	Wh/m2 day
01/01	0	486	663	0,03	-2,4
02/01	0	0	487	0	-2,3
03/01	0	17772	495	0,14	8,5
04/01	0	0	508	0	-2,5
05/01	0	573	515	0,021	-1
06/01	0	-1292	419	0,226	15,7
07/01	0	35661	554	0,172	10,4
08/01	0	-5141	479	0,075	3,4
09/01	0	-24186	474	0,238	15,6
10/01	0	-12119	463	0,236	15,7
11/01	0	0	587	0	-3,6
12/01	0	31247	557	0,22	13,9
13/01	0	16672	337	0,17	12,9
14/01	0	5454	651	0,157	7,4
15/01	0	702	688	0,156	6,8
16/01	0	7854	666	0,205	10,9
17/01	0	14166	495	0,157	9,7
18/01	0	14498	610	0,143	7,1
19/01	0	-6548	751	0,037	-3,2
20/01	0	-667	714	0,181	8,3
21/01	0	0	723	0	-5,5
22/01	0	-6848	726	0,072	-0,2
23/01	0	0	798	0	-6,5
24/01	0	0	522	0	-2,7
25/01	0	0	273	0	0,7
26/01	0	-18540	587	0,14	6,7

Esporta dati
CHIUDI

***GH*, i gradi ora giornalieri riferiti al setpoint scelto [°C];**
***V$_w$*, il wind run secondo l'orientamento del tetto [m];**
***Z$_{irr}$*, l'irraggiamento per la sola quota ortogonale al tetto [Wh m^{-2}];**
***V$_{asv}$*, la velocità media dell'aria nella camera di ventilazione [m s^{-1}];**
***q*, l'energia termica specifica entrante dalla copertura [Wh m^{-2}].**

Risultati (3/3)

$$q = a_0 + a_1 Z_{irr} + a_2 GH + a_3 V_{ASV} + a_4 V_w$$

```
Date; GH; VW; Zirr; Vasv; q
01/01/2017;0;-3798,44393858224;2798,92852096494;0,0687173418719642;-29,0381701718562
02/01/2017;0;-2267,86505011956;1790,78711602085;0,021514917231545;-18,6610948775617
03/01/2017;0;15492,399645526;2588,8450184085;0,10556210875404;-23,0754862663808
04/01/2017;0;-15777,2867471958;3075,66099114791;0,119241849733086;-29,2092430203239
05/01/2017;0;64244,328142279;3082,52308856999;0,312278059996723;-13,5669835026212
06/01/2017;0;802,350613827888;3523,87369448387;0,0712034104418175;-38,798597952598
07/01/2017;0;-17966,744306899;3416,10368865982;0,0924471858946552;-35,9696154851305
08/01/2017;0;-6203,43274172645;3171,96887861293;0,0603553798967088;-34,8576701607456
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10/01/2017;0;29018,0432376518;720,776404830175;0,155253378810415;6,67905831366742
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12/01/2017;0;17791,4061481218;607,35144363931;0,111948422836017;4,81091967589823
13/01/2017;0;-9883,31296422249;474,489605764289;0,165446175673169;10,2996730887443
14/01/2017;0;-3545,33105480388;3600,73993804842;0,122454301201549;-36,0455891408811
15/01/2017;0;-3383,36465243211;1858,91527062937;0,067823102010073l;-16,1153481618561
16/01/2017;0;75563,2344499277;2227,95264677648;0,307340345869816;-1,97541735366854
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18/01/2017;0;76822,3244958694;3575,0247933018;0,356186149589458;-16,8702906863971
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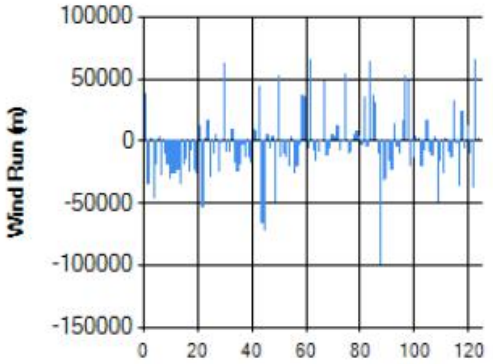
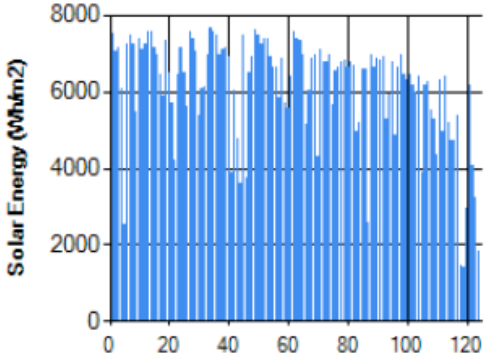
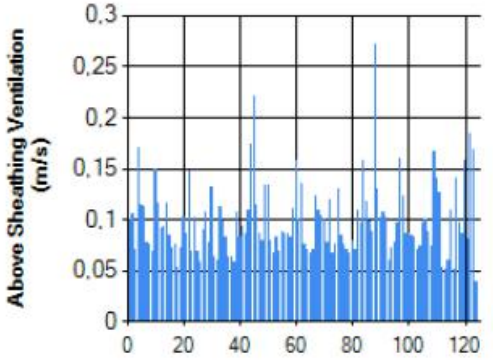
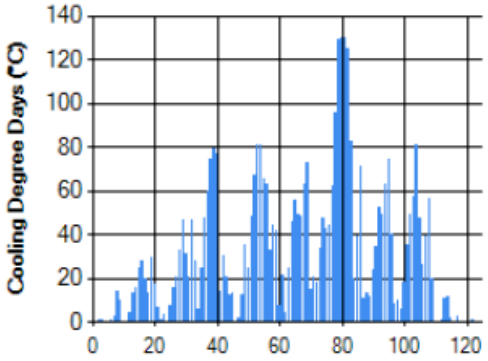
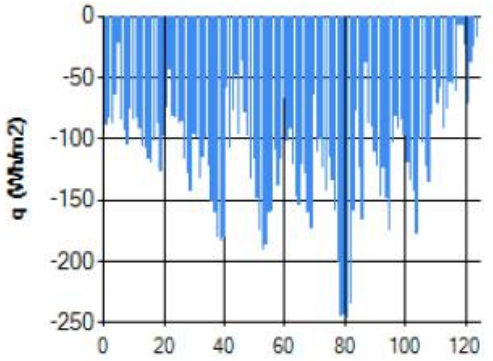
SENSAPIRO V1.0 - LIFE HEROTILE PROJECT
Setpoint temperature: 27°C
Decrement factor: 0,93631
Numbers of layers: 4
Roof pitch: 20deg
Roof orientation: 180°deg
Roof type: Portoghese HERO
Eave type: semi-open
Location: Ferrara
Roof average height: 8m
Urban setting: urban medium density
Period: 15/5-15/9 124 days



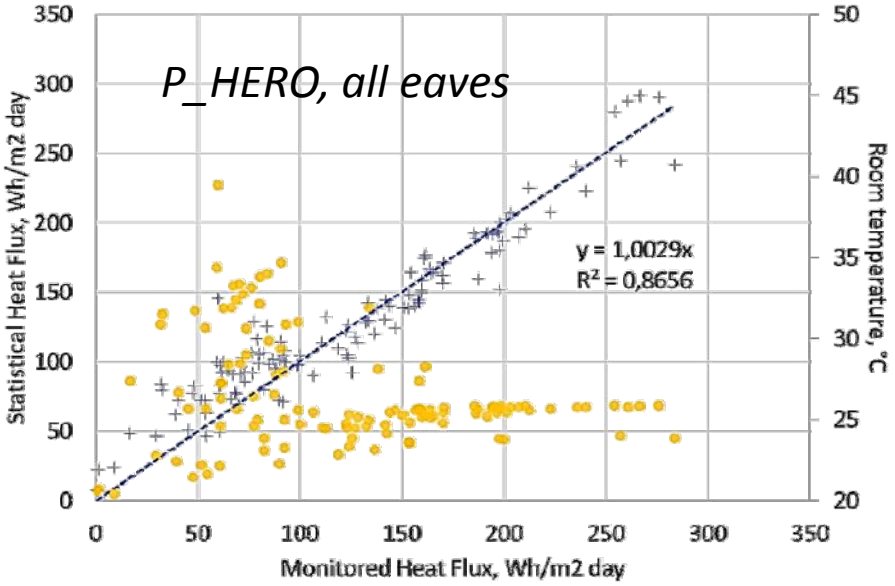


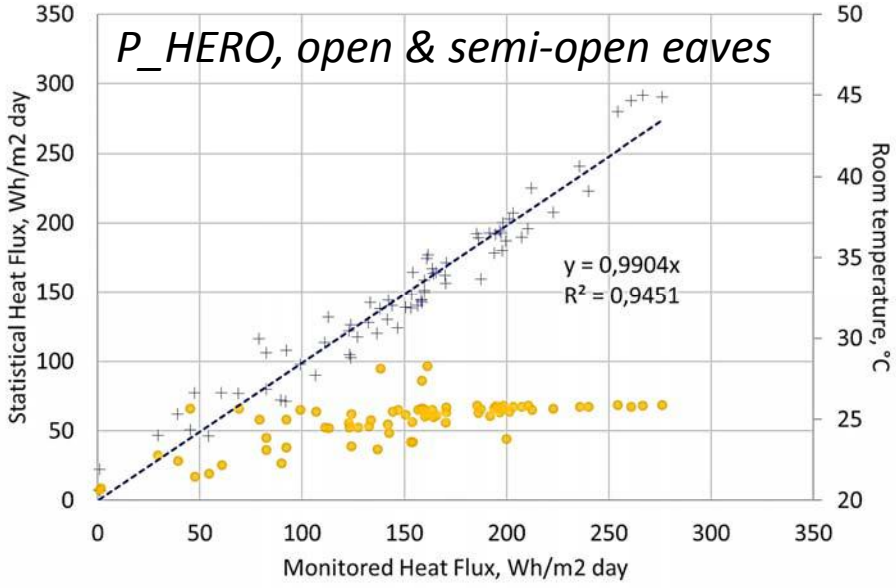






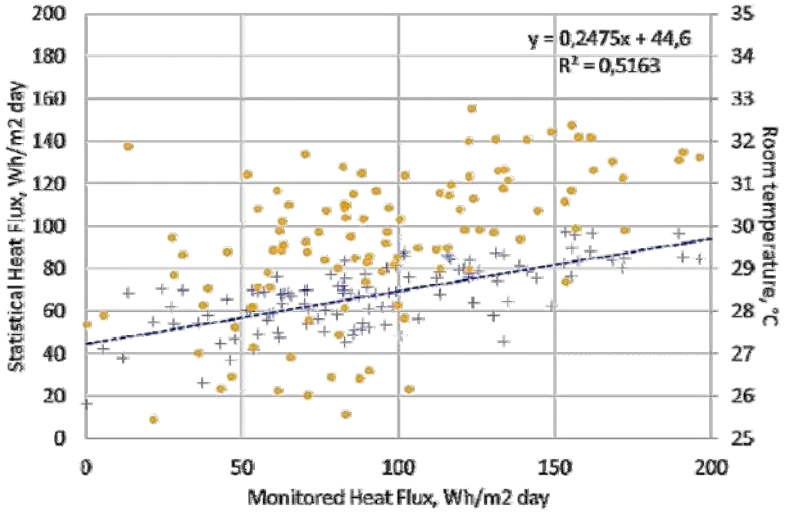
Ferrara 2017

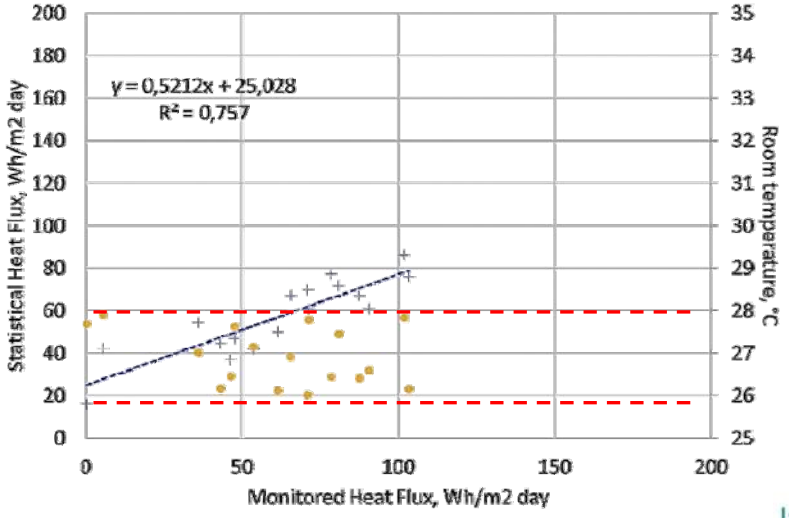




Saragozza 2018

portoghese standard, non ventilata





Grazie

lifeHEROTILE

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