Airtightness versus local mentality in Greece

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ABSTRACT

Low or Zero Energy buildings are becoming increasingly popular and the use of passive-house principles are providing a solid foundation for achieving energy consumption targets and good indoor quality. However, this design methodology has been well received in central and northern Europe than in south and the Mediterranean, where people are used to houses that are open to the external environment. This habit is in contrast to the basic principles of the good airtightness, the energy efficiency and the achievement of a good Indoor Air Quality.
Because of this mentality and the current construction methods, it is noticed according to the European Environment Agency, that the average heating consumption of residential properties in Greece is almost double than in Sweden. To unlearn a given situation is more difficult than to learn something new and the current crisis is an opportunity to investigate new design principles and methodologies, to face the critical construction issues and challenges, to develop practical manufacturing solutions as well as to communicate that the good airtightness is not a disadvantage.
A Zero Energy building procedure in southern and Mediterranean climate, should balance the proper design requirements with the, often contradictory, local ways and demands of using the buildings. Furthermore, this procedure should place much importance on the human experience and satisfaction with the building's architecture and user's habits, rather than just the national or European legislations based on numbers.
A building needs a good airtightness but this requirement sounds like a negative and deterrent request to the local communities. The research of the last 12 years over the Greek experience, constitutes a practical field of experiments with different results to take under consideration and avoid to compromise the way to a low-consumption society with the proper Indoor Air Quality.
Especially regarding the airtightness, there cannot be any achievement without the acceptance and the contribution of the local population. This research is based on BlowerDoor tests applied in Greece since 2010, reflects the situation on the existing building stock and along with interviews of home owners and professionals (engineers, architects, contractors) provide conclusions and suggestions for similar cases.

KEYWORDS

Airtightness, zero-energy, South Europe buildings, local mentality, Greece

1 INTRODUCTION

This presentation is the recording of the first 100 airtight tests in Greece, from 2010 until today. The inspections were carried out in private homes and in large-scale commercial buildings, of different construction dates, renovated or not, in various cities of the country and on islands. Most of the inspections were carried out in the area of Attica and in the city of Athens. From the above recording, very useful conclusions emerge about how energy sustainable the cities that have been built in the last 60 years are, their energy footprint and above all the habits of the population that lives in them. Wasteful buildings have created wasteful people and habits with the result that there is a risk of failure of energy upgrade moves, energy savings and a substantial reduction of the energy footprint. The construction techniques used in the past have evolved little, resulting in the use of state-of-the-art materials with old techniques. This results in the failure of new materials and often has more negative consequences than the problems they are trying to solve. A specific method was followed to record the results and the final conclusions described at the end. In addition to recording the inspections, building users, engineers and craftsmen were interviewed on the subject of the airtight housing.

2 METHODOLOGY OF AIRTIGHTNESS MEASUREMENTS

The date of construction of the building, the surfaces of each apartment and the volume were recorded. Subsequently, the facilities that had remained in the same conditions since they were built were separated, those that underwent a general renovation and the new premises. Most of the new construction was large commercial buildings, a 100-room hotel and LIDL stores. The following (Table 1) is a detailed list of all measurements with the corresponding results.

Table 1: The list of the first 100 measurements in Greece

Nr	Day of measurement	n50 (Air changes per Hour)	Residential use	Commercial use	Year of Construction	Refurbished / Existing or New	Location
1	26/04/10	3,58	1		1998	E	Athens
2	23/05/10	7,80	1		1985	E	Athens
3	14/05/11	3,08	1		1985	E	Athens
4	01/12/11	7,65		1	1980	E	Athens
5	26/02/12	6,12	1		1983	E	Athens
6	17/05/12	5,84	1		1980	E	Athens
7	30/11/12	4,02	1		1982	E	Athens
8	05/12/12	4,34	1		2004	E	Athens
9	17/02/13	14,58	1		1968	E	Athens
10	04/06/13	12,11	1		1982	E	Athens
11	13/07/13	6,91	1		1982	E	Athens
12	05/05/14	7,49	1		1977	E	Athens
13	14/05/14	6,85	1		1985	E	Athens
14	19/08/14	4,95	1		1968	E	Athens
15	24/10/14	8,65	1		1985	E	Athens
16	14/12/14	6,54	1		1985	E	Athens
17	12/02/15	11,53	1		1968	E	Athens
18	29/03/15	9,85	1		1983	E	Athens
19	17/05/15	5,64	1		2013	E	Athens
20	23/07/15	7,56	1		1985	E	Athens
21	26/10/15	6,24	1		1980	E	Athens
22	02/11/15	4,56	1		1973	R	Athens
23	04/02/16	5,36	1		1968	E	Athens
24	29/04/16	4,65	1		1985	R	Athens

25	08/05/16	3,95	1			1995	R	Athens
26	09/07/16	4,58	1			1994	E	Athens
27	23/09/16	4,96	1			2011	E	Athens
28	15/01/17	6,58	1			1968	E	Athens
29	24/02/17	8,59	1			1975	E	Athens
30	03/04/17	4,61		1		2017	N	Mitilini
31	29/05/17	3,98	1			1987	R	Athens
32	27/08/17	5,78	1			1968	E	Athens
33	23/11/17	6,85	1			1968	E	Athens
34	12/02/18	1,12		1		2017	N	Tripoli
35	14/03/18	3,97	1			1969	R	Athens
36	26/03/18	5,48	1			1985	R	Athens
37	05/04/18	6,58	1			1974	E	Athens
38	15/05/18	1,68		1		2017	N	Athens
39	18/10/18	1,41		1		2018	N	Mesologgi
40	03/02/19	6,45	1			1960	R	Athens
41	23/02/19	0,98		1		2019	N	Amaliada
42	05/03/19	3,00	1			1974	R	Athens
43	26/04/19	2,58	1			1990	R	Athens
44	07/05/19	4,85	1			1972	R	Athens
45	13/06/19	5,60	1			1985	E	Athens
46	27/10/19	4,80	1			1998	E	Athens
47	25/11/19	6,50	1			1989	E	Athens
48	07/12/19	1,31		1		2019	N	Arta
49	14/12/19	3,54	1			1975	R	Athens
50	01/02/20	1,68		1		2020	N	Limnos
51	01/04/20	8,89		1		2020	N	Kos
52	30/04/20	3,25	1			2005	R	Athens
53	04/05/20	1,45		1		2020	N	Moudania
54	30/05/20	1,32		1		2020	N	Kasandria
55	15/06/20	4,52	1			1974	E	Athens
56	28/07/20	4,68	1			1985	R	Athens
57	09/08/20	3,62	1			1995	R	Athens
58	03/11/20	1,44		1		2020	N	Athens
59	18/04/21	2,65	1			1972	R	Athens
60	17/05/21	1,24		1		2021	N	Thasos
61	06/06/21	3,56	1			1972	E	Athens
62	12/06/21	2,89	1			1974	R	Athens
63	15/06/21	6,45	1			1985	E	Athens
64	04/07/21	4,58	1			2005	R	Athens
65	13/07/21	0,90	1			1992	R	Voula
66	15/07/21	4,06	1			1995	E	Athens
67	27/08/21	3,58	1			1972	R	Athens
68	11/09/21	2,96	1			1973	R	Athens
69	15/09/21	6,27	1			1975	E	Athens
70	18/09/21	4,65	1			2005	E	Athens
71	27/09/21	3,54	1			1972	R	Athens
72	04/10/21	4,85	1			1972	E	Athens
73	07/10/21	6,35	1			2004	E	Athens
74	13/10/21	2,45	1			1985	R	Athens
75	19/10/21	1,56	1			2009	R	Athens
76	27/10/21	6,52	1			1995	E	Athens
77	31/10/21	3,54	1			1997	R	Athens
78	04/11/21	2,58	1			1985	R	Athens
79	16/11/21	3,65	1			1999	R	Athens
80	25/11/21	4,75	1			1972	E	Athens
81	29/11/21	3,65	1			1982	R	Athens
82	09/12/21	5,89	1			2021	N	Egina

83	11/12/21	4,85	1		1986	E	Athens
84	28/12/21	2,75	1		2015	R	Athens
85	13/01/22	4,77	1		1980	R	Voula
86	17/01/22	6,45	1		1976	E	Athens
87	19/01/22	3,25	1		2011	R	Athens
88	23/01/22	2,94	1		2015	R	Athens
89	29/01/22	5,23	1		1985	E	Athens
90	03/02/22	4,32	1		1978	E	Athens
91	05/02/22	5,28	1		1995	E	Athens
92	07/02/22	3,25	1		2005	R	Athens
93	10/02/22	6,45	1		1969	E	Athens
94	11/02/22	2,54	1		1972	R	Athens
95	16/02/22	6,98	1		2005	E	Athens
96	18/02/22	5,85	1		1972	E	Athens
97	19/02/22	8,65	1		1969	E	Athens
98	09/03/22	4,85	1		2015	E	Athens
99	29/03/22	8,95	1		1967	E	Athens
100	04/04/22	1,08		1	2021	N	Sparta

From the above list, 52 existing buildings (Figure 1) were measured in which no additional intervention had been made since they were constructed. It is observed that the average air exchange is n50 = **6.49.**

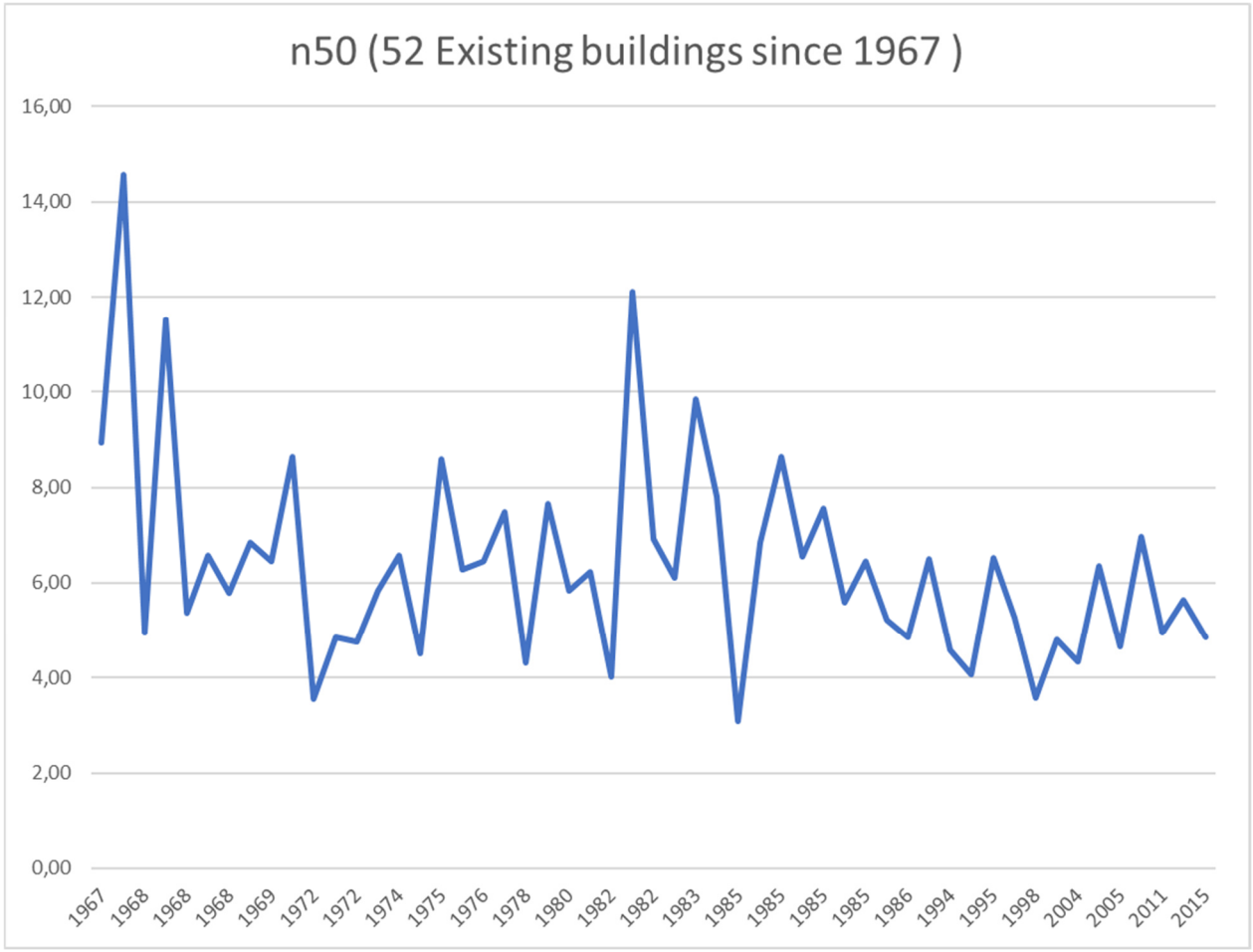

Figure 1: The airtightness of 52 premises build from 1967 to 2015

It is observed (Figure 2) that in the 14 new buildings that were measured and constructed from 2017 until today, the average air exchange is n50 = **2.44.**

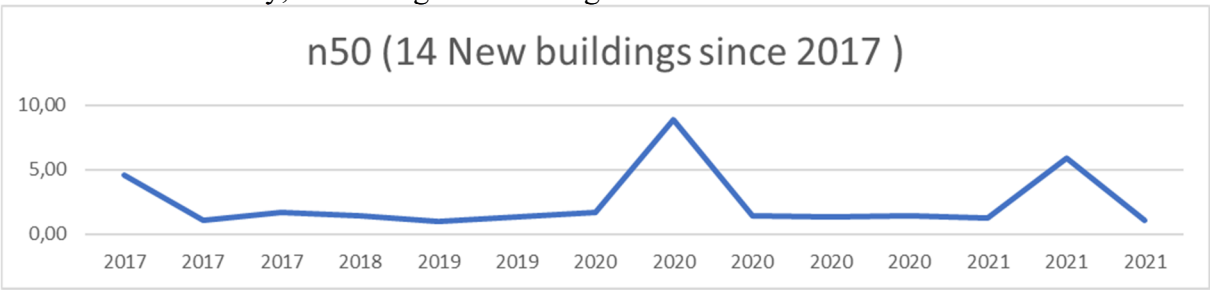

Figure 2: The airtightness of 52 14 new built premise from 2017 to 2021

Finally, (Figure 3) 34 buildings were originally constructed from 1960 and renovated in recent years. To a large extent, the apartments that were renovated from 2000 until today, chose to replace their sliding frames with opening ones. The average air exchange is n50 = **3.43**.

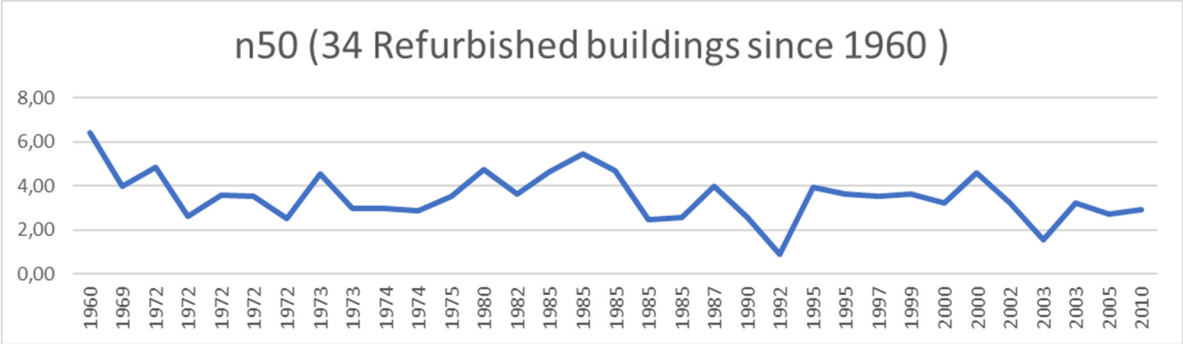

Figure 3: The airtightness of 34 premises built from 1960 to 2010

The trend of airtight controls in Greece (Figure 4) shows an upward trend, without being particularly impressive, given that they do not exceed 30 measurements per year.

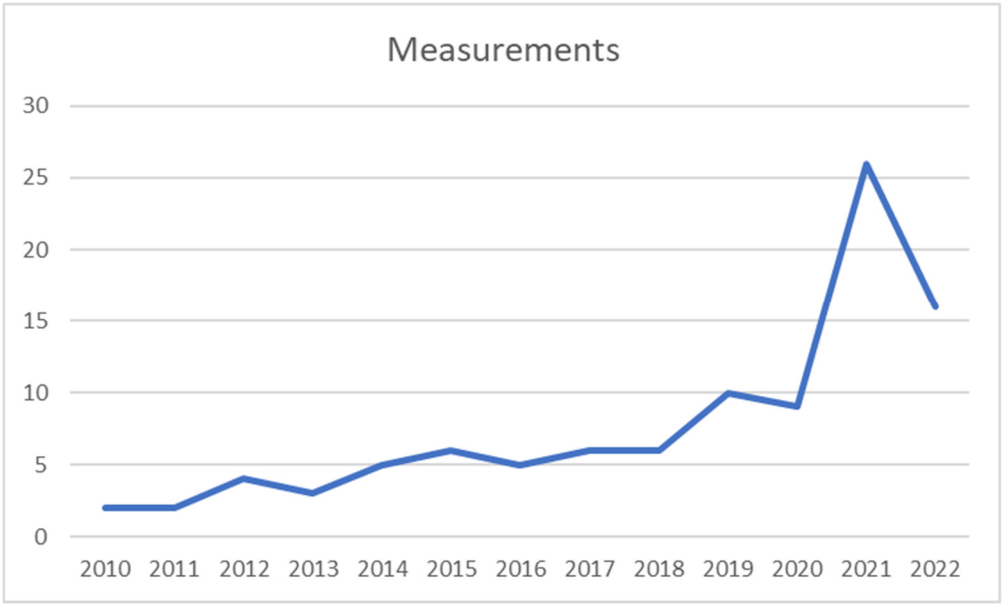

Figure 4: The trend of airtight controls in Greece since 2010

The following graph shows the maximum and minimum temperatures in the region of Attica during a year (Figure 5). The green line indicates the ideal temperature for the internal comfort of man. The red line indicates the registered temperatures in Attica (region of Athens). It is confirmed that the requirement for space heating is about five months a year (from November to March), the requirement for cooling is about two months (July and August) while for the remaining five months the buildings in Attica are enough to stay with windows open and achieve ideal temperatures indoors.

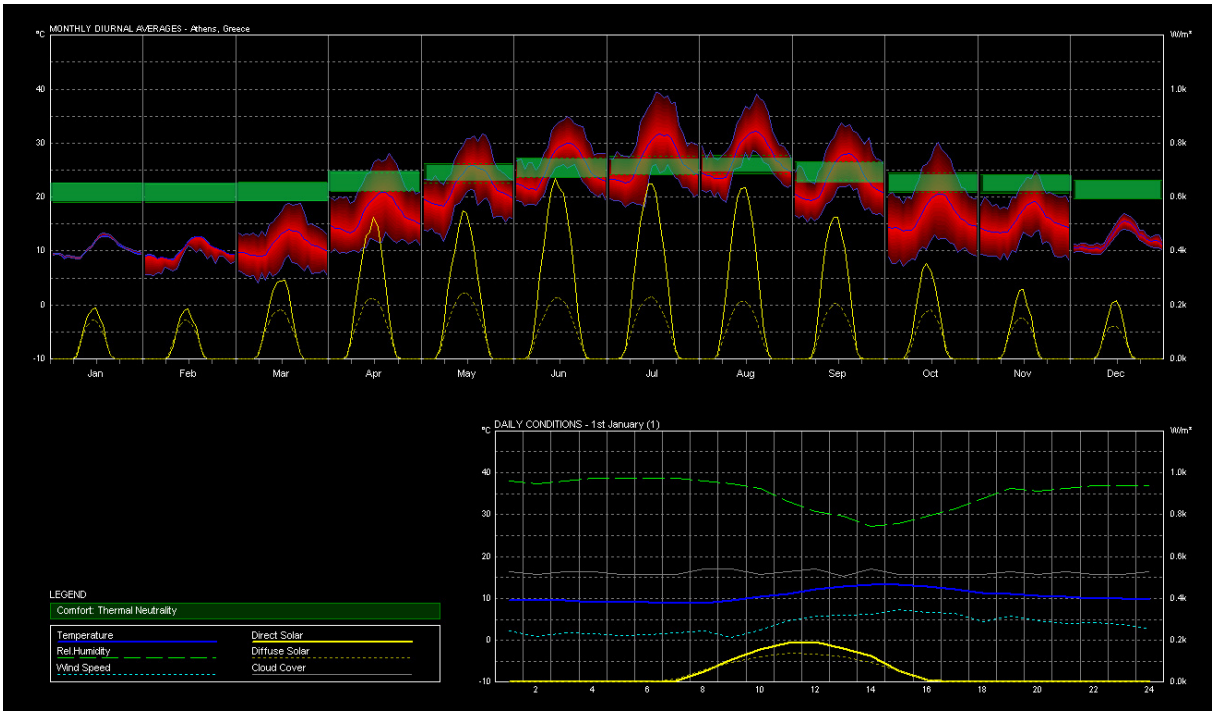

Figure 5: The monthly diurnal average temperature in Attica

According to the Hellenic Statistical Authority (www.statistics.gr) from 2018 to 2020, the number of building permits increased from 15,342 to 18,928 (approximately 23.4%) while the new buildable areas for the same period increased from 3,532 .675 m² to 4,129,281 m² (approximately 17.9%). At the same time there is a large building stock (4,105,637 buildings) last recorded in 2011 of which 2,990,324 are residential. The rest are public buildings (schools, hospitals), shops and business premises, hotels, churches, etc. Of the above total number of buildings, only 19,968 are made of wood, 34,868 are made of metal, 723,249 are made of stone and 2,368,696 are made of concrete and bricks. The average primary energy consumption in Greek residential buildings is 306.55 KWh/m², in temporary accommodation buildings (hotels) it is 451.06 KWh/m², while in public buildings it is 791.32 KWh/m². New buildings under construction are required to issue an energy certificate but there is no prevention, specification or requirement to check the airtightness of the building envelope. It is obvious that there has been a noticeable improvement in the airtightness of the buildings since 1960 but this is due more to the advanced technology of the frames and not to the new sealing practices of the buildings. It is observed that a renovated apartment reduces its losses by only 47.15% (from 6.49 to 3.43) compared to its original condition. A modern construction is only improved by 28.86% compared to a renovated property of 1960 (from 3.43 to 2.44) while it achieves only 24.59% of its target given that the ideal airtightness would be n50 = 0,6.

The above numerical results lead to the conclusion that no matter how advanced technological products appear in a market, if end users do not want to achieve the goal of airtightness, any move towards sustainability and green growth will be incomplete and in the end much more harmful. This is because huge sums of money will have been spent on research, materials and labor without ever being amortized due to poor application and use.

2.1 Recording of the habits and the local mentality

In addition to the above measurements of the buildings, the habits of the residents were also recorded. The results show that to a large extent the term airtightness creates a very negative impression and that the largest percentage 56.3% live in buildings that do not offer suitable living conditions. It is also striking that heat losses in both winter and summer, due to air changes, are considered acceptable and necessary, even though they cause large increases in energy costs. The conflicting opinion on the term airtightness and the use of a sealed building are also interested to keep and shows the general confusion about the subject. The following list (Table 2) shows the answers of the respondents.

Table 2: The results of the questionnaire

Question	Options	% Replies
How do you feel by the phrase: "the house is hermetically sealed"?		
	- Positive feeling of hygiene	0.0%
	- Negative feeling, that I am "suffocating" and lacking oxygen	87.5%
	- Neutral feeling, doesn't affect me	12.5%
How attractive is a fully airtight house to you?		
	- Very much, I want it.	50.0%
	- Not at all, I would avoid it	43.8%
	- Indifferent	6.2%
How effectively do you think you ventilate your home when it's very cold?		
	- Fairly effective, I ventilate as much as needed	50.0%
	- Very effective, I ventilate all day	25.0%
	- Not so efficient because we are away most of the time	25.0%
How effectively do you think you ventilate your home when it's very hot?		
	- Fairly effective, I ventilate as much as needed	50.0%
	- Very effectively, windows and patio doors are almost always half-closed or tilted	18.8%
	- Not so efficient because we are away most of the time	31.3%
Do you think ventilation burdens energy consumption in large temperature differences in winter or summer?		
	- Yes, it is burdensome to some extent but it is a necessary necessity of the house, so it is a waste in an acceptable context	62.5%
	- No, it does not particularly burden energy consumption and daily ventilation is mandatory	12.5%
	- Yes, it greatly burdens energy consumption and I keep the house as long as it becomes closed in large temperature differences	25.0%
In your home, do you think you have more problems in winter or in summer?		
	- In the winter when it is very cold	18.8%
	- In the summer during the great heat	18.8%
	- In both periods	56.3%

-	We have no problem in any case, we live with satisfactory thermal comfort conditions	6.1%
How often do you ventilate your house in the very cold winter? (In 24 hours)		
-	Less than an hour	56.2%
-	Between one and two hours	25.0%
-	More than 3 hours	0.0%
-	There is always a small window always open and tilted (usually the bathroom)	18.8%
In the summer with the air conditioner running, do you leave any windows open?		
-	No, when the air conditioner is on, all windows and patio doors are closed	56.8%
-	Yes, there is always a tilted window or a balcony door ajar	43.8%
In the summer with the use of the air conditioner, do you feel discomfort and some unpleasant conditions? (Headache, dizziness, dry mouth or other?)		
-	No, I don't mind using the air conditioner in the summer at all	31.3%
-	Yes, that's why I only keep the A/C on for a few hours in the hot weather and with the windows open	68.8%
Have you noticed in the winter in extreme cold, raising the internal temperature but still not feeling well and feeling that something is wrong? (Chills, cold fingers, discomfort, etc.)?		
-	No, whenever the heating works, we have no problem	50.0%
-	Yes, although the heating works, we feel some kind of discomfort	50.0%
Place in order of priority and importance (from 1 the most to 4 the least), the reasons why we need to ventilate our home		
-	To renew oxygen and create well-being	62.0%
-	To prevent the formation of liquefaction and mold	23.0%
-	For sanitization (elimination of germs and prevention of diseases)	12.0%
-	To remove the stench	3.0%

3 CONCLUSIONS

The main conclusion is that the concept of good airtightness in the Mediterranean regions refers more to a negative feeling and therefore is a deterrent effect for the population. For this reason, special emphasis should be placed on informing, educating and raising public awareness, starting even from a young age in primary schools. It should be widely understood that the daily way of life and behavior of a population has a direct effect and consequence on the economy, health, and even the energy independence of a country. Regulations and laws are not enough if they are not understood, just as it is not enough to supply expensive and advanced products without proper training of applicants and users. Unfortunately, it turns out that in hot climates, habits and lifestyle create conditions that lead to greater energy waste and a worse quality of life.

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