The contribution of ventilation on the energy performance of small residential buildings in the Mediterranean region

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Abstract

Efficient ventilation is an effective method for reducing thermal loads inside buildings, thus decreasing cooling energy consumption. This is especially relevant in warmer climates. Therefore, it is important to better understand the role that different ventilation parameters play on air-conditioning consumptions. This study analyzes the effect of three different ventilation parameters – air flow rate, minimum indoor temperature and indoor-outdoor temperature difference – on the energy performance of buildings in the Mediterranean region. A set of 500 residential building geometries was randomly generated and the energy consumption for different combinations of ventilation parameters was assessed in sixteen distinct locations. Results suggested that the ventilation specifications that minimize air-conditioning energy consumption fall within similar values for all the evaluated locations: ventilation rates of at least 10 air changes per hour, a minimum indoor temperature for ventilation slightly below the building's cooling setpoint, and a low indoor-to-outdoor temperature difference. It was also found that, in lower latitudes, the buildings' energy performance tended to become similar, thus reducing the impact of their geometry and orientation. These results may help building practitioners to infer the most adequate ventilation strategies to implement, since this study is not limited to specific ventilation methods.

Keywords: residential buildings, ventilation, Mediterranean climate, dynamic simulation

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1. Introduction

Energy consumption for space cooling is rising in the national balance of several countries [1–3]. Therefore, the application of active cooling in residential buildings is becoming more common practice nowadays, especially in warmer climates, since it is considered to be a necessary condition to obtain good thermal comfort. A major challenge that is arising in the Mediterranean

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region, new buildings included, is the increase of overheating even during the mild hot seasons, resulting in a significant change in energy use [4]. Ventilation is an effective strategy for offsetting the thermal loads by cooling the building making use of colder outdoor air, thus helping to reduce active cooling energy consumption [5]. The most usual strategies are to increase ventilation air flow rates and night ventilation. The driving forces can be either natural (free cooling) or mechanical (forced). Mechanical ventilation is often used to ensure high flow rates, and natural ventilation is proven to be an effective low-cost solution for space conditioning, especially in cooling-dominant climates [6, 7]. However, since natural ventilation can lead to high fluctuations in air change rates, hybrid ventilation systems are normally employed to ensure a constant airflow rate, consisting in the combination of mechanical and natural forces in a two-mode system where the operating mode varies according to the season and daily fluctuations [8]. With regards to the use of ventilation cooling in the Mediterranean region, Chiesa and Grosso [3] found that the cooling reduction potential derived from the application of controlled natural ventilation as a heat dissipation technique is fairly high in all of the Mediterranean basin: in office buildings, the cooling energy intensity (CEI) with mechanical ventilation during occupation hours at the minimum airflow rate requirement ranges from $52.8\,\mathrm{kW \cdot h \cdot m^{-2}}$ in Malaga to $79.7\,\mathrm{kW \cdot h \cdot m^{-2}}$ in Tripoli. CEI values tend to increase with envelope transmittance (decreasing insulation) all over the Mediterranean basin. When introducing wind-driven controlled natural ventilation (CNV), CEI values decrease with increasing insulation. The potential reduction of CEI due to CNV ranges from 22 % in Cairo to 69 % in Malaga. These conclusions are supported by Chen et al. [9], who also refer that natural ventilation presents high potential to reduce building energy consumption and to improve indoor environment in the Mediterranean climate: the maximum natural ventilation potential in the Mediterranean ranges from 3000 to 6000 hours in a typical year (out of 8760 h). Gil-Baez et al. [10] performed experimental tests on new school buildings in southern Spain, and found that natural ventilation allowed for an 18 % to 33 % primary energy saving in relation to mechanical ventilation, while maintaining comfort levels in classrooms.

Night ventilation is one of the most efficient passive cooling techniques. Heracleous and Michael [11] state that it is an effective strategy for reducing the risk of overheating in southern European buildings. It is based on the circulation of cooler ambient air to decrease both the temperature of the indoor air and of the building's structure. Its efficiency is mainly based on the difference between the outdoor and indoor air temperatures during the night period. However, for a given place, the cooling potential of night ventilation techniques depends on the air flow rate, the thermal capacity of the building and the appropriate coupling of the thermal mass and air flow [12]. Most of the studies on night ventilation techniques conclude that its application in free floating buildings may decrease the next-day-peak indoor temperature by up to 3 °C. In addition, when applied in air-conditioned buildings, a considerable reduction in peak cooling may be expected [12]. For example, Santamouris et al. [12] concluded that the higher the cooling demand of the building, the higher the potential contribution of night ventilation under specific boundary conditions. In residential buildings, the yearly cooling load may decrease up to $40\,\mathrm{kW \cdot h \cdot m^{-2}}$, with an average contribution close to $12\,\mathrm{kW \cdot h \cdot m^{-2}}$, due to night ventilation. The authors also found the global usability of the energy stored during the night increases as a function of the air flow rate, especially for buildings with higher cooling loads. A flow rate increase from 2 ACH to 30 ACH may contribute to 7.3 and 19.4 additional $\mathrm{kW \cdot h \cdot m^{-2}}$ per year for buildings having a cooling load of approximately $30\,\mathrm{kW \cdot h \cdot m^{-2}}$ and $80\,\mathrm{kW \cdot h \cdot m^{-2}}$, respectively. However, the specific contribution of night ventilation per unit of air flow (1 ACH) decreases significantly for higher air flow rates. In particular, the annual energy contribution of night ventilation per unit of air change is close to 3.3, 2.5, 1.8, 1.2 and $0.7\,\mathrm{kW \cdot h \cdot m^{-2}}$, for 2, 5, 10, 20 and 30 ACH, respectively. Faggianelli et al. [13] investigated the use of thermal breezes, characterized by moderate speeds and well-defined direction, to improve natural cross-ventilation techniques in buildings in Mediterranean coastal zones, and concluded that even if the airflow varies greatly, a minimal control of opening surfaces is sufficient to maintain the airflow rate in a comfortable range. Guarino et al. [4] concluded that ventilation cooling moderately improves the load match and reduces electricity demand from the grid more effectively, under the appropriate climatic indoor conditions. The authors reported increases in the load cover factor through natural ventilative cooling from 0.5 % to 5 %, and a reduction in energy import from 1 % up to 22 % in the case of a Sicilian residential building. Michael et al. [14] investigated the influence of natural ventilation on the indoor thermal environment in the residential vernacular architecture of Cyprus during the hot summer period. The results show that night ventilation reduces peak indoor air temperatures and also improves indoor thermal conditions the following day. Furthermore, cross ventilation during night-time takes full advantage of the relatively low outdoor air temperature and cools down the building envelope in the best possible way. Despite these studies, the majority of the research work has been conducted on non-residential buildings, resulting from the limitations regarding indoor privacy as well as the operational period of the building at night [15].

The body of research focused on residential ventilation cooling in the Mediterranean region tends to cover a limited number of building cases and/or address specific ventilation techniques (mainly night ventilation). Therefore, their conclusions are specific to the showcase in analysis, being unable to provide a statistical representation of their findings. Moreover, in most studies, the spotlight typically falls on the measurement and assessment of the ventilation rate, rather than on the impact of ventilation on energy demand [16]. Hence, the aim of this study is to statistically analyze the overall effect of a set of ventilation parameters (air change rate and temperature setpoints) over a large set of buildings in different climate locations, to assess the most adequate ventilation parameters for each case, thus preventing limitations due to specific ventilation techniques and averting geometry-biased results originating from the use of a single or limited type of building. In order to achieve this, a set of 500 residential building geometries were randomly generated and their energy consumption for air-conditioning was evaluated for all combinations of three ventilation parameters (air change rate, minimum indoor setpoint temperature, and indoor-outdoor air temperature difference) for sixteen Mediterranean locations, thus totalizing 1 080 000 building simulations. Therefore, the analysis presented in this study covers a wide range of building geometries in distinct Mediterranean locations, assessing the most suitable ventilation rate and setpoint temperatures that would help decrease energy consumption. This methodology of generating a synthetic dataset of a large number of buildings to analyze the impact of ventilation parameters on the energy performance of buildings is a novel and unique contribution to the field. Moreover, the results may be helpful during the early design stages in defining the optimal ventilation technique. In addition, the ability to evaluate the impact of ventilation is a significant contribute to the improvement of building energy modeling, providing insightful indicators for indoor air quality and the disaggregation of energy demand.

2. Methodology

To determine the impact of ventilation on a building's energy performance, a three-step methodology was adopted. In the first step, a generative design method produced 500 alternative building solutions, which satisfy the same geometric and topologic requirements. The U-values for the exterior opaque and transparent elements of the generated buildings correspond to the results obtained from a previous study [17], in which the most adequate thermal transmittance values were determined for the same Mediterranean locations. The second step entailed using dynamic simulation to evaluate the buildings' annual energy demand for air-conditioning. Each one of the 500 residential buildings had different combinations of ventilation parameters for each climate location, totalizing 1 080 000 different building simulations. The buildings' geometry data, construction specifications, and performance evaluation were stored in a dataset. In the third step, a statistical analysis of the dataset was carried out to compare the impact of the different ventilation parameters on the buildings' energy performance for each location.

2.1. Generative design method

The generative design method used to produce the alternative building geometries was the Evolutionary Program for the Space Allocation Problem (EPSAP) [18–21]. This algorithm finds the indoor floor plan layout in each story according to geometric and topologic specifications for each space and opening. In this study, the building specifications correspond to a two-story family house comprising a hall, a living room, a kitchen, and a bathroom on the ground floor level, and a corridor, a master bedroom, a double bedroom, a single bedroom and a bathroom on the upper floor, with a staircase connecting both levels (see Refs. [17, 22] for the complete and detailed specifications). Generally, each space has a defined type (circulation, service, or living), relative importance (ranking each space's importance in comparison to the remaining spaces from none to max), the storeys that it is assigned to, minimum space floor side dimension, minimum space floor area, and ratios for the space floor sides. Moreover, each space may have one or more exterior openings, by specifying the opening type (door, gate, or window), minimum width, minimum height, and relative vertical position of the opening to the story floor level. The geometry of the interior openings is also specified, in addition to their adjacency relations between contiguous spaces. Fig. 1 depicts some building geometry examples generated by the EPSAP algorithm for the specifications described.

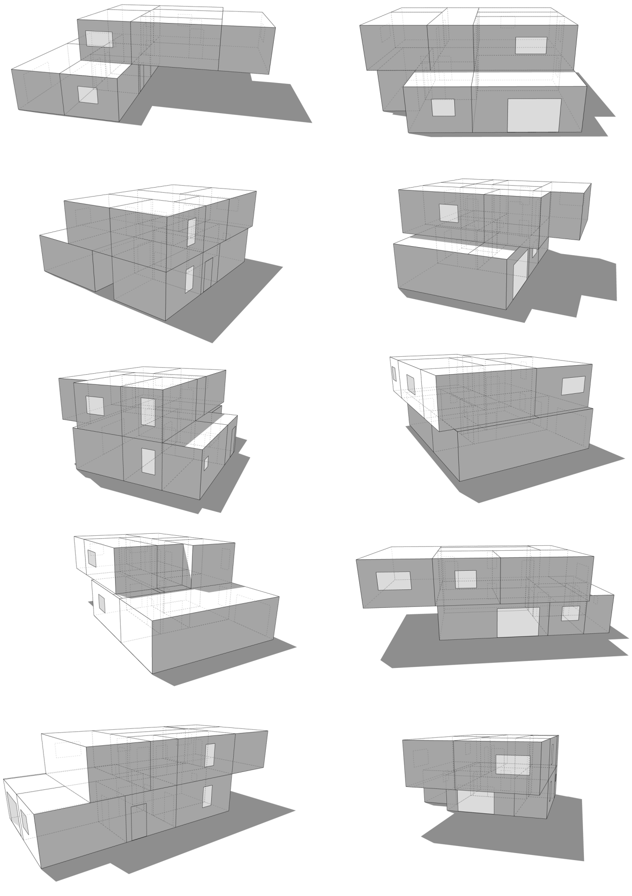


Fig. 1. Ten examples of two-story buildings generated by the EPSAP algorithm.

2.2. Building performance evaluation

After each building generation run, the building's performance evaluation was carried out using a coupled dynamic simulation engine [23, 24]. The EnergyPlus (version 9.0.1) software was used for a detailed multi-zone energy performance assessment. In order to carry out this performance evaluation, the building specifications correspond to the geometry restraints and requirements defined above (see subsection 2.1), as well as the construction system, internal gains and HVAC specifications along with climate data, which are detailed in the following sections. Since different specifications would not allow for a rigorous comparison, the same usage profiles were considered for all generated buildings, in order to compare results for different regional locations using exactly the same base building.

2.2.1. Construction system

The construction system defines the building's constructive elements and their thermophysical properties. The building construction elements and respective properties are presented in Tables 1 and 2. The thermal mass of all exterior opaque elements apart from doors (exterior walls, roofs, and suspended slabs – Table 2) is considered to be equivalent to that of an interior slab (see Table 1), while their U-values correspond to the most adequate values obtained in a previous study [17], in which the impact of the thermal transmittance variation on the building design and energy performance was assessed for the same Mediterranean locations. The same U-values are also applied to the exterior doors. Regarding the exterior transparent elements, a constant solar heat gain coefficient (SHGC) of 0.6 was considered, while the U-values also correspond to the best results obtained in the previous study [17].

Table 1. Building's construction elements.

Element	**Layer**	**Thickness** (m)	k $(\mathrm{W \cdot m^{-1} \cdot K^{-1}})$	ρ $(\mathrm{kg \cdot m^{-3}})$	c_p $(\mathrm{J \cdot kg^{-1} \cdot K^{-1}})$	U $(\mathrm{W \cdot m^{-2} \cdot K^{-1}})$
Interior wall	Finishing layer	0.02	0.22	950	840	4.50
	Structural layer	0.07	1.73	2243	836.8	
	Finishing layer	0.02	0.22	950	840	
Interior slab	Finishing layer	0.02	0.22	950	840	2.84
	Structural layer	0.2	1.73	2245.6	836.8	
	Regulation layer	0.01	0.22	950	840	
	Finishing layer	0.02	0.2	825	2385	
Ground floor	Structural layer	0.2	1.73	2245.6	836.8	0.44
	Insulation layer	0.08	0.04	32.1	836.8	
	Filling layer	0.02	0.8	1600	840	
	Regulation layer	0.01	0.22	950	840	
	Finishing layer	0.02	0.2	825	2385	
Interior door	Finishing layer	0.005	0.2	825	2385	2.01
	Structural layer	0.03	0.067	430	1260	
	Finishing layer	0.005	0.2	825	2385	

k– thermal conductivity, ρ – density, c_p – specific heat, U – thermal transmittance

2.2.2. Internal gains and HVAC specifications

The internal gains and HVAC specifications are defined by the occupancy, lighting, equipment, and HVAC usage profiles that are specified for each thermal zone (*i.e.*, inhabited spaces in the building), and are identical for all the generated buildings.

Table 2. Thermal transmittance of the building's envelope elements.

Location		U ($\mathrm{W \cdot m^{-2} \cdot K^{-1}}$)	
City	**Country**	**Opaque elements**[a]	**Exterior windows**[b]
Venice	ITA	0.10	0.40
Marseille	FRA	0.20	0.80
Podgorica	MNE	0.20	0.80
Istanbul	TUR	0.15	0.60
Naples	ITA	0.25	1.00
Valencia	ESP	0.35	1.40
Izmir	TUR	0.25	1.00
Athens	GRC	0.25	1.00
Tunis	TUN	0.35	1.40
Algiers	DZA	0.40	1.60
Malaga	ESP	0.55	2.20
Larnaca	CYP	0.45	1.80
Casablanca	MAR	0.55	2.20
Tripoli	LBY	0.35	1.40
Tel Aviv	ISR	0.50	2.00
Alexandria	EGY	0.65	2.60

[a] – Internal mass equivalent to Interior slab in Table 1.
[b] – SHGC = 0.6.
U – thermal transmittance, SHGC – solar heat gain coefficient

The occupancy patterns and the operation profiles of lighting and equipment are based on the building's typology. The building is considered a single-family dwelling occupied by five people. The lighting and equipment design levels and schedules are based on the building zone typology and occupancy. In addition, the lighting schedules are also based on the window shading profiles: PVC roller shutters cover the windows during night-time, and daylighting controls dim the light intensity in spaces with exterior windows, switching them off when daylight illuminance is above 300 lx (this is a "simulation procedure" that allows to adjust the lighting values according to available daylight in each latitude, since the electric lighting profiles are identical in all locations). The value of 300 lx was used to guarantee adequate illuminance for home working activities [25, 26]. Further details on the occupancy, lighting and equipment can be found in Refs. [17, 22].

Regarding the HVAC specifications, heating and cooling are only considered in the living room and bedrooms. For this purpose, the EnergyPlus ideal loads air system model is used to simulate an ideal air-conditioned system [27], thus making it possible to directly evaluate the spaces' heating and cooling requirements. The heating/cooling availability schedule for each space is defined by the respective occupancy pattern and the indoor temperature thermostat setpoints for cooling and heating are 25.0 °C and 20.0 °C, respectively, for all the case studies. A 0.6 air changes per hour (ACH) exhaust rate is considered for the kitchen and the bathrooms, with a flow rate profile equivalent to the occupancy schedules defined for these spaces, while 0.2 ACH and 0.1 ACH are considered for the outdoor air infiltration into zones with and without exterior openings, respectively. As far as the living areas (living room and bedrooms), it is the aim of the present study to assess the ventilation specification for these.

2.2.3. Climate data

The selected sixteen climate locations are dispersed around the Mediterranean Sea, covering the coastal areas of the Southern European, Northern African, and Middle East countries: Venice (Italy, ITA), Marseille (France, FRA), Podgorica (Montenegro, MNE), Istanbul (Turkey, TUR), Naples (ITA), Valencia (Spain, ESP), Izmir (TUR), Athens (Greece, GRC), Tunis (Tunisia, TUN), Algiers (Algeria, DZA), Malaga (ESP), Larnaca (Cyprus, CYP), Casablanca (Morocco, MAR), Tripoli (Libya, LBY), Tel Aviv (Israel, ISR), and Alexandria (Egypt, EGY). According to the Köppen-Geiger World Map climate classification [28], the locations are characterized as being humid subtropical (mild with no dry season and hot summer), except for Malaga (ESP), which has a Mediterranean climate (dry hot summer and mild winter), and Tripoli (LBY), which is classified as hot subtropical steppe. The corresponding weather data was used, which is available in the EnergyPlus website [29]. Further information on the climate locations can be found in Ref. [17] (latitude, longitude, altitude, and climate type designation).

2.3. Statistical analysis

A synthetic dataset was created with the buildings' geometry data (number of stories, spaces, openings, surface areas of the elements, volumes, and other geometric information), construction data (the physical properties of transparent and opaque elements), and performance data (electric energy consumption, water consumption, thermal discomfort, and thermal energy production). The dataset totalized 1 080 000 simulations; *i.e.*, 500 buildings per combination of ventilation parameters (135) per location (16). An *a priori* statistical t-test was carried out to compute the minimum sample size, which was $n \geq 327$, for a probability of 95 % and effect size $d = 0.2$ with two tails (the significance of average energy consumption for all buildings per ventilation parameters per location was $p < 0.01$). The dataset is publicly available online (see Ref. [30]).

The statistical analysis consisted in evaluating each group by location and energy consumption for air-conditioning – total energy, heating energy, and cooling energy –, according to three ventilation parameters: air changes per hour (ACH), minimum indoor temperature for ventilation to occur (T_{min}), and minimum indoor-outdoor temperature difference for ventilation to occur (ΔT). These three parameters are assigned to the building's living areas and refer to ventilation with outdoor conditions. ACH represents the ventilation rate, *i.e.*, the flow rate of outdoor air entering the building's living areas; T_{min} represents the indoor temperature below which ventilation is not allowed, thus preventing over-cooling the spaces below the specified value; and ΔT represents the difference between indoor and outdoor air temperatures below which ventilation is shutoff, which allows ventilation to be stopped if the outside temperature is too warm and could potentially heat the spaces. The ventilation rate ranges from 0.1 ACH to 30 ACH, T_{min} ranges from 21 °C to 25 °C, and ΔT ranges from 1 °C to 3 °C. The combination of $T_{min} > 20\,°\text{C}$ and $\Delta T > 0\,°\text{C}$ results in the ventilation occurring only when the outside air temperature is lower than the indoor temperature and the latter is above the heating setpoint, which is typically associated with night ventilation during the cooling season (although not necessarily limited to this: for example, it can allow for ventilation during the daytime in the heating season, as long as the indoor and outdoor temperature conditions are favorable). Therefore, the analysis is not restricted to a ventilation technique (*e.g.*, only natural or forced ventilation; only night ventilation), but is rather general, thus allowing to understand the most adequate ventilation rates and temperature setpoints for each location, and how these parameters have an influence on each other.

3. Results and Discussion

Figs. 2 and 3 display the results for total energy consumption for air-conditioning ($\text{MW} \cdot \text{h}$) per subgroup of ventilation parameter – ACH, T_{min} and ΔT. The locations are sorted in descending order of latitude from top to bottom rows, and in each row there are three subgroups corresponding to the ΔT values: 1 °C, 2 °C and 3 °C. The horizontal axis of each subgroup corresponds to the ACH variation, ranging from 0.1 ACH to 30 ACH, and the vertical axis refers to the T_{min} range, varying from 21 °C to 25 °C. Each energy consumption result (*i.e.*, each cell) represents the average of all 500 buildings for the ventilation parameters and location considered. The respective standard deviation (σ) of energy consumption is also presented in each cell. The energy consumption values falling within the interval of $0.01\,\text{MW} \cdot \text{h}$ of the lowest value are marked with a black rectangle.

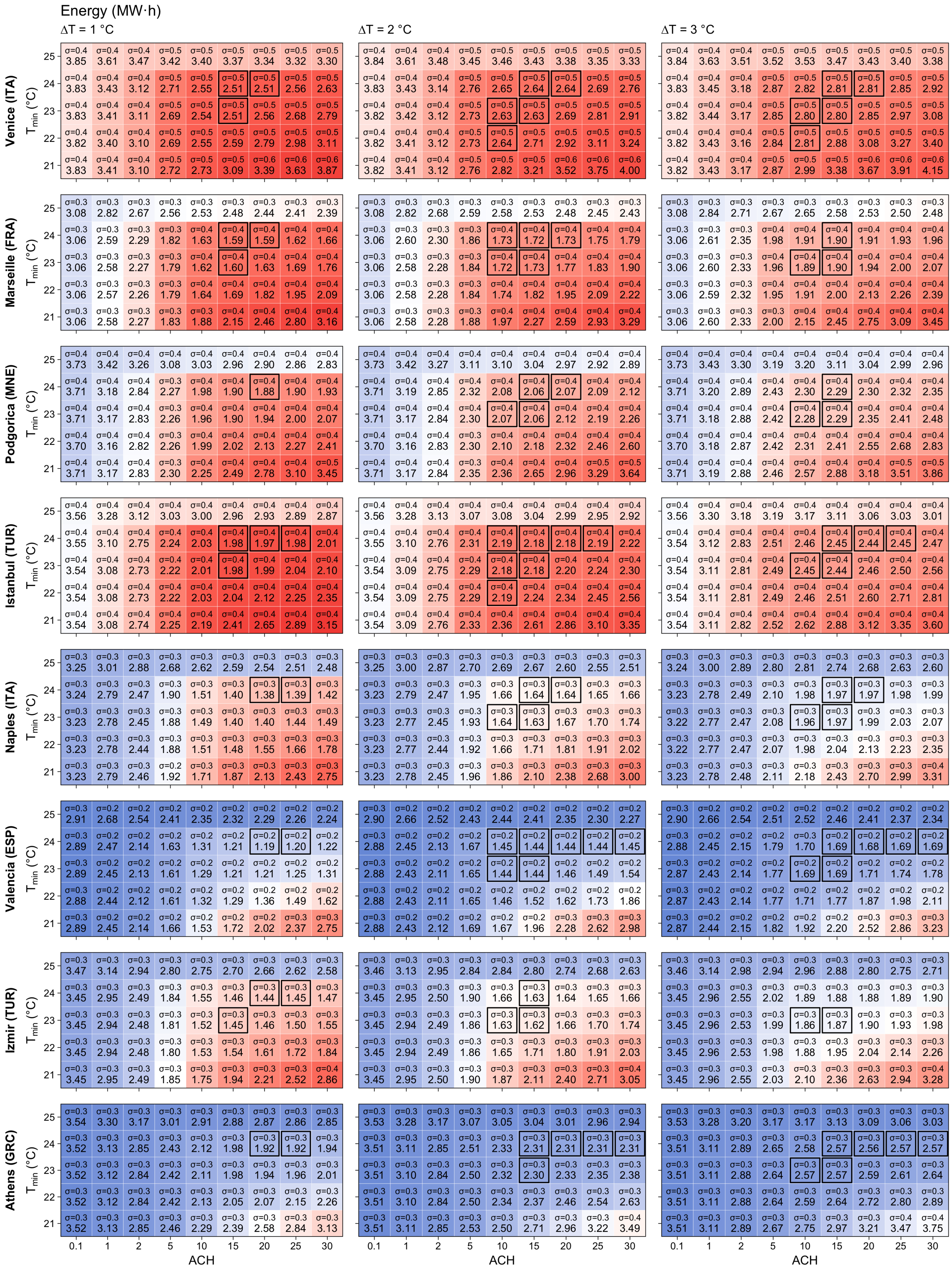
Total energy consumption for air-conditioning (Figs. 2 and 3) represents the sum of heating and cooling energy consumptions. As expected, in northern latitudes, total energy consumption relates mostly to heating (dark red). In middle latitudes, the tendency is for a more balanced ratio between heating and cooling, thus the lighter blue and red, and even white shades. And, in southern locations, total energy consumption is mostly dominated by cooling demands (dark blue). The best results (black rectangles) are obtained for T_{min} values typically 1 °C to 2 °C below the cooling setpoint, which indicates that a slight over-cooling compensates (in cooling energy savings) heating energy that may be necessary due to lower indoor temperatures. Along the same lines, higher ventilation rates are also preferable (typically over 10 ACH), as long as T_{min} is not too low. It is also noticeable that, overall, higher ACH values translate into a lower cooling demand in total energy consumption. ΔT presents a significant influence: higher ΔT values increase total energy demand, thus not being favorable. The higher the indoor-outdoor temperature difference below which ventilation is not allowed, the less the ventilation tends to occur, thus hampering the cooling effect. This increases the cooling energy demand and, consequently, total energy demand (since ΔT has no effect on the heating demand, as explained below). The results also show that, in southern locations, lower consumptions translate into smaller performance ranges between buildings (lower σ values). This indicates that the differences in the buildings' geometry and orientation tend to become less impacting on their energy performance as the performance increases. Therefore, in the southern latitudes, as long as the ventilation specifications allow for a high energy performance, the geometry and orientation of the building tend to have less impact.

Specifically, regarding heating energy consumption (Figs. A.1 and A.2), the results indicate that the higher the ACH values are, the higher the heating energy consumption becomes, for all locations, which is more noticeable as the T_{min} value is lower. For the highest T_{min} value (25.0 °C), there is practically no heating energy consumption variation, since it corresponds to the air-conditioning setpoint for cooling. Below this threshold (*i.e.*, for lower T_{min} values), ventilation occurs for indoor temperature values lower than the cooling setpoint, thus over-cooling the spaces, which may cause the heating system to operate (a more pronounced feature for higher ventilation rates, as expected). This is observable independently of the ΔT value; *i.e.*, ΔT does not have any influence on the heating energy consumption results. Therefore, in relation to heating consumption, higher ventilation rates have a negative effect on T_{min} values below the cooling setpoint. For lower latitudes, it is also noticeable that buildings in each location present similar heating consumption among them, as the standard deviation tends to decrease. Furthermore, independently of the location, lower heating energy consumption translates into similar energy performance between buildings (lower σ values).

As far as cooling energy consumption (Figs. A.3 and A.4) the opposite occurs, as higher ACH and lower T_{min} values result in a higher ventilation cooling effect, which decreases energy consumption for cooling purposes. However, the effect of decreasing T_{min} is mainly noticed between 25 °C and 24 °C, remaining practically constant for lower T_{min} values. This denotes that the simple fact of allowing ventilation below the cooling setpoint is already significant, especially for higher ACH values. In contrast with the heating results, ΔT now presents a significant influence: higher ΔT values increase cooling demand, since if the indoor-outdoor temperature difference below which ventilation is not allowed increases, the ventilation does not occur as often, thus hampering the cooling effect. This is more noticeable for higher ventilation rates, since low ACH values already hamper the ventilation cooling effect on a large scale, almost independently of the ΔT. It is also noticeable that, for each location, lower cooling energy consumptions correspond to more similar energy performance between buildings (lower σ values). The analysis only considered the total cooling load. However, the effect of its latent component cannot be disregarded, as the relative humidity – which introduces a latent cooling load – presents a different evolution in each of the sixteen climate locations. Nevertheless, although the latent load effect in the total cooling demand is different across the assessed locations, the conclusions presented above are valid independently of the latent load. *I.e.*, the total cooling load results are similar to those of the sensible cooling load, although in a non-linear way (due to the varying effect of the latent load). The disaggregated cooling load values are available for each location in the public dataset (see Ref. [30]).

The results indicate that ventilation rates of at least 10 ACH (above this threshold the results tend to stabilize) and T_{min} values slightly below the cooling setpoint together with a low ΔT value lead to better energy performances, independently of the location. There is no direct correlation between the variations of energy consumption and the buildings' latitude, apart from the tendency for heating consumption to lower in lower latitudes; the cooling and total energy consumptions do not present a defined tendency. The evolution of energy consumption for heating and cooling tend to respectively follow the heating and cooling degree-days variation across the different latitudes, as can be seen in Fig. 4. If one considers a coefficient of determination (R^2) for the correlations between energy consumption and the degree-days, as well as the classification intervals $[0, 0.2[$ – very weak, $[0.2, 0.4[$ – weak, $[0.4, 0.6[$ – moderate, $[0.6, 0.8[$ – strong, and $[0.8, 1]$ – very strong, then heating and cooling energy consumptions reveal very strong correlations ($R^2 = 0.89$ and $R^2 = 0.98$, respectively), although the correlation for total energy consumption is rather moderate ($R^2 = 0.58$).

Although the ventilation setpoint temperature results (T_{min} and ΔT) seem reasonable, care should be taken regarding the ACH results. While higher ventilation rates help to reduce cooling energy consumption (and, in this case, total energy consumption), very high values may represent excessive draft and some cool sensation of discomfort having in mind the expected occupants' clothing in the summer season, especially when dealing with residential buildings; which may raise concern regarding indoor thermal comfort. Nevertheless, some studies refer to the application of high ventilation rates. For example, Faggianelli et al. [13] reported that tracer gas measurements in seaside buildings in Mediterranean coastal zones show that high air change rates are reached by cross ventilation during the day (higher than 25 ACH), while night ventilation provides more moderate results with air change rates close to 10 ACH. Moreover, in a study focused on night ventilation techniques, Santamouris et al. [12] reported that in 31 of the 214 real residential buildings analyzed in Greece, the ventilation rate was about 20 ACH, and in 29 of them it was around 30 ACH. In this regard, an analysis of the ACH variation impact on the reduction of total energy consumption was carried out for the previously presented results (in comparison with a basis of 0.1 ACH), considering an optimal T_{min} of 24 °C and an optimal ΔT of 1 °C. The results are presented in Fig. 5 for each location. One is able to verify that the reduction in energy consumption is at least 19 % for 2 ACH, and at least 29 % for 5 ACH, surpassing 50 % in Algiers (DZA), Malaga (ESP), Casablanca (MAR) and Tel Aviv (ISR). In these four locations, ventilation is the most effective in reducing energy consumption, independently of the ventilation rate, since they present



Energy (MW·h)

Venice (ITA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.85	σ=0.4 3.61	σ=0.4 3.47	σ=0.5 3.42	σ=0.5 3.40	σ=0.5 3.37	σ=0.5 3.34	σ=0.5 3.32	σ=0.5 3.30
24	σ=0.4 3.83	σ=0.4 3.43	σ=0.4 3.12	σ=0.5 2.71	σ=0.5 2.55	σ=0.5 2.51	σ=0.5 2.51	σ=0.5 2.56	σ=0.5 2.63
23	σ=0.4 3.83	σ=0.4 3.41	σ=0.4 3.11	σ=0.5 2.69	σ=0.5 2.54	σ=0.5 2.51	σ=0.5 2.56	σ=0.5 2.68	σ=0.5 2.79
22	σ=0.4 3.82	σ=0.4 3.40	σ=0.4 3.10	σ=0.5 2.69	σ=0.5 2.55	σ=0.5 2.59	σ=0.5 2.79	σ=0.5 2.98	σ=0.5 3.11
21	σ=0.4 3.83	σ=0.4 3.41	σ=0.4 3.10	σ=0.5 2.72	σ=0.5 2.73	σ=0.5 3.09	σ=0.6 3.39	σ=0.6 3.63	σ=0.6 3.87

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.84	σ=0.4 3.61	σ=0.4 3.48	σ=0.5 3.45	σ=0.5 3.46	σ=0.5 3.43	σ=0.5 3.38	σ=0.5 3.35	σ=0.5 3.33
24	σ=0.4 3.83	σ=0.4 3.43	σ=0.4 3.14	σ=0.5 2.76	σ=0.5 2.65	σ=0.5 2.64	σ=0.5 2.64	σ=0.5 2.69	σ=0.5 2.76
23	σ=0.4 3.82	σ=0.4 3.42	σ=0.4 3.12	σ=0.5 2.73	σ=0.5 2.63	σ=0.5 2.63	σ=0.5 2.69	σ=0.5 2.81	σ=0.5 2.91
22	σ=0.4 3.82	σ=0.4 3.41	σ=0.4 3.12	σ=0.5 2.73	σ=0.5 2.64	σ=0.5 2.71	σ=0.5 2.92	σ=0.5 3.11	σ=0.5 3.24
21	σ=0.4 3.82	σ=0.4 3.41	σ=0.4 3.12	σ=0.5 2.76	σ=0.5 2.82	σ=0.5 3.21	σ=0.6 3.52	σ=0.6 3.75	σ=0.6 4.00

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.84	σ=0.4 3.63	σ=0.4 3.51	σ=0.5 3.52	σ=0.5 3.53	σ=0.5 3.47	σ=0.5 3.43	σ=0.5 3.40	σ=0.5 3.38
24	σ=0.4 3.83	σ=0.4 3.45	σ=0.4 3.18	σ=0.5 2.87	σ=0.5 2.82	σ=0.5 2.81	σ=0.5 2.81	σ=0.5 2.85	σ=0.5 2.92
23	σ=0.4 3.82	σ=0.4 3.44	σ=0.4 3.17	σ=0.5 2.85	σ=0.5 2.80	σ=0.5 2.80	σ=0.5 2.85	σ=0.5 2.97	σ=0.5 3.08
22	σ=0.4 3.82	σ=0.4 3.43	σ=0.4 3.16	σ=0.5 2.84	σ=0.5 2.81	σ=0.5 2.88	σ=0.5 3.08	σ=0.5 3.27	σ=0.5 3.40
21	σ=0.4 3.82	σ=0.4 3.43	σ=0.4 3.17	σ=0.5 2.87	σ=0.5 2.99	σ=0.5 3.38	σ=0.6 3.67	σ=0.6 3.91	σ=0.6 4.15

Marseille (FRA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.08	σ=0.3 2.82	σ=0.3 2.67	σ=0.3 2.56	σ=0.3 2.53	σ=0.3 2.48	σ=0.3 2.44	σ=0.3 2.41	σ=0.3 2.39
24	σ=0.3 3.06	σ=0.3 2.59	σ=0.3 2.29	σ=0.3 1.82	σ=0.4 1.63	σ=0.4 1.59	σ=0.4 1.59	σ=0.4 1.62	σ=0.4 1.66
23	σ=0.3 3.06	σ=0.3 2.58	σ=0.3 2.27	σ=0.3 1.79	σ=0.4 1.62	σ=0.4 1.60	σ=0.4 1.63	σ=0.4 1.69	σ=0.4 1.76
22	σ=0.3 3.06	σ=0.3 2.57	σ=0.3 2.26	σ=0.3 1.79	σ=0.4 1.64	σ=0.4 1.69	σ=0.4 1.82	σ=0.4 1.95	σ=0.4 2.09
21	σ=0.3 3.06	σ=0.3 2.58	σ=0.3 2.27	σ=0.3 1.83	σ=0.3 1.88	σ=0.4 2.15	σ=0.4 2.46	σ=0.4 2.80	σ=0.4 3.16

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.08	σ=0.3 2.82	σ=0.3 2.68	σ=0.3 2.59	σ=0.3 2.58	σ=0.3 2.53	σ=0.3 2.48	σ=0.3 2.45	σ=0.3 2.43
24	σ=0.3 3.06	σ=0.3 2.60	σ=0.3 2.30	σ=0.3 1.86	σ=0.4 1.73	σ=0.4 1.72	σ=0.4 1.73	σ=0.4 1.75	σ=0.4 1.79
23	σ=0.3 3.06	σ=0.3 2.58	σ=0.3 2.28	σ=0.3 1.84	σ=0.4 1.72	σ=0.4 1.73	σ=0.4 1.77	σ=0.4 1.83	σ=0.4 1.90
22	σ=0.3 3.06	σ=0.3 2.58	σ=0.3 2.28	σ=0.3 1.84	σ=0.4 1.74	σ=0.4 1.82	σ=0.4 1.95	σ=0.4 2.09	σ=0.4 2.22
21	σ=0.3 3.06	σ=0.3 2.58	σ=0.3 2.28	σ=0.3 1.88	σ=0.4 1.97	σ=0.4 2.27	σ=0.4 2.59	σ=0.4 2.93	σ=0.4 3.29

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.08	σ=0.3 2.84	σ=0.3 2.71	σ=0.3 2.67	σ=0.3 2.65	σ=0.3 2.58	σ=0.3 2.53	σ=0.3 2.50	σ=0.3 2.48
24	σ=0.3 3.06	σ=0.3 2.61	σ=0.3 2.35	σ=0.4 1.98	σ=0.4 1.91	σ=0.4 1.90	σ=0.4 1.91	σ=0.4 1.93	σ=0.4 1.96
23	σ=0.3 3.06	σ=0.3 2.60	σ=0.3 2.33	σ=0.4 1.96	σ=0.4 1.89	σ=0.4 1.90	σ=0.4 1.94	σ=0.4 2.00	σ=0.4 2.07
22	σ=0.3 3.06	σ=0.3 2.59	σ=0.3 2.32	σ=0.4 1.95	σ=0.4 1.91	σ=0.4 2.00	σ=0.4 2.13	σ=0.4 2.26	σ=0.4 2.39
21	σ=0.3 3.06	σ=0.3 2.60	σ=0.3 2.33	σ=0.3 2.00	σ=0.4 2.15	σ=0.4 2.45	σ=0.4 2.75	σ=0.4 3.09	σ=0.4 3.45

Podgorica (MNE)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.73	σ=0.4 3.42	σ=0.4 3.26	σ=0.4 3.08	σ=0.4 3.03	σ=0.4 2.96	σ=0.4 2.90	σ=0.4 2.86	σ=0.4 2.83
24	σ=0.4 3.71	σ=0.4 3.18	σ=0.4 2.84	σ=0.3 2.27	σ=0.4 1.98	σ=0.4 1.90	σ=0.4 1.88	σ=0.4 1.90	σ=0.4 1.93
23	σ=0.4 3.71	σ=0.4 3.17	σ=0.4 2.83	σ=0.3 2.26	σ=0.4 1.96	σ=0.4 1.90	σ=0.4 1.94	σ=0.4 2.00	σ=0.4 2.07
22	σ=0.4 3.70	σ=0.4 3.16	σ=0.4 2.82	σ=0.3 2.26	σ=0.4 1.99	σ=0.4 2.02	σ=0.4 2.13	σ=0.4 2.27	σ=0.4 2.41
21	σ=0.4 3.71	σ=0.4 3.17	σ=0.4 2.83	σ=0.3 2.30	σ=0.4 2.25	σ=0.4 2.49	σ=0.4 2.78	σ=0.4 3.10	σ=0.5 3.45

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.73	σ=0.4 3.42	σ=0.4 3.27	σ=0.4 3.11	σ=0.4 3.10	σ=0.4 3.04	σ=0.4 2.97	σ=0.4 2.92	σ=0.4 2.89
24	σ=0.4 3.71	σ=0.4 3.19	σ=0.4 2.85	σ=0.4 2.32	σ=0.4 2.08	σ=0.4 2.06	σ=0.4 2.07	σ=0.4 2.09	σ=0.4 2.12
23	σ=0.4 3.71	σ=0.4 3.17	σ=0.4 2.84	σ=0.4 2.30	σ=0.4 2.07	σ=0.4 2.06	σ=0.4 2.12	σ=0.4 2.19	σ=0.4 2.26
22	σ=0.4 3.70	σ=0.4 3.16	σ=0.4 2.83	σ=0.3 2.30	σ=0.4 2.10	σ=0.4 2.18	σ=0.4 2.32	σ=0.4 2.46	σ=0.4 2.60
21	σ=0.4 3.71	σ=0.4 3.17	σ=0.4 2.84	σ=0.3 2.35	σ=0.4 2.36	σ=0.4 2.65	σ=0.4 2.96	σ=0.5 3.29	σ=0.5 3.64

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.73	σ=0.4 3.43	σ=0.4 3.30	σ=0.4 3.19	σ=0.4 3.20	σ=0.4 3.11	σ=0.4 3.04	σ=0.4 2.99	σ=0.4 2.96
24	σ=0.4 3.71	σ=0.4 3.20	σ=0.4 2.89	σ=0.4 2.43	σ=0.4 2.30	σ=0.4 2.29	σ=0.4 2.30	σ=0.4 2.32	σ=0.4 2.35
23	σ=0.4 3.71	σ=0.4 3.18	σ=0.4 2.88	σ=0.4 2.42	σ=0.4 2.28	σ=0.4 2.29	σ=0.4 2.35	σ=0.4 2.41	σ=0.4 2.48
22	σ=0.4 3.70	σ=0.4 3.18	σ=0.4 2.87	σ=0.4 2.42	σ=0.4 2.31	σ=0.4 2.41	σ=0.4 2.55	σ=0.4 2.68	σ=0.4 2.83
21	σ=0.4 3.71	σ=0.4 3.19	σ=0.4 2.88	σ=0.4 2.46	σ=0.4 2.57	σ=0.4 2.88	σ=0.4 3.18	σ=0.5 3.51	σ=0.5 3.86

Istanbul (TUR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.56	σ=0.4 3.28	σ=0.4 3.12	σ=0.4 3.03	σ=0.4 3.00	σ=0.4 2.96	σ=0.4 2.93	σ=0.4 2.89	σ=0.4 2.87
24	σ=0.4 3.55	σ=0.4 3.10	σ=0.4 2.75	σ=0.4 2.24	σ=0.4 2.03	σ=0.4 1.98	σ=0.4 1.97	σ=0.4 1.98	σ=0.4 2.01
23	σ=0.4 3.54	σ=0.4 3.08	σ=0.4 2.73	σ=0.4 2.22	σ=0.4 2.01	σ=0.4 1.98	σ=0.4 1.99	σ=0.4 2.04	σ=0.4 2.10
22	σ=0.4 3.54	σ=0.4 3.08	σ=0.4 2.73	σ=0.4 2.22	σ=0.4 2.03	σ=0.4 2.04	σ=0.4 2.12	σ=0.4 2.25	σ=0.4 2.35
21	σ=0.4 3.54	σ=0.4 3.08	σ=0.4 2.74	σ=0.4 2.25	σ=0.4 2.19	σ=0.4 2.41	σ=0.4 2.65	σ=0.4 2.89	σ=0.4 3.15

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.56	σ=0.4 3.28	σ=0.4 3.13	σ=0.4 3.07	σ=0.4 3.08	σ=0.4 3.04	σ=0.4 2.99	σ=0.4 2.95	σ=0.4 2.92
24	σ=0.4 3.55	σ=0.4 3.10	σ=0.4 2.76	σ=0.4 2.31	σ=0.4 2.19	σ=0.4 2.18	σ=0.4 2.18	σ=0.4 2.19	σ=0.4 2.22
23	σ=0.4 3.54	σ=0.4 3.09	σ=0.4 2.75	σ=0.4 2.29	σ=0.4 2.18	σ=0.4 2.18	σ=0.4 2.20	σ=0.4 2.24	σ=0.4 2.30
22	σ=0.4 3.54	σ=0.4 3.09	σ=0.4 2.75	σ=0.4 2.29	σ=0.4 2.19	σ=0.4 2.24	σ=0.4 2.34	σ=0.4 2.45	σ=0.4 2.56
21	σ=0.4 3.54	σ=0.4 3.09	σ=0.4 2.76	σ=0.4 2.33	σ=0.4 2.36	σ=0.4 2.61	σ=0.4 2.86	σ=0.4 3.10	σ=0.4 3.35

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.4 3.56	σ=0.4 3.30	σ=0.4 3.18	σ=0.4 3.19	σ=0.4 3.17	σ=0.4 3.11	σ=0.4 3.06	σ=0.4 3.03	σ=0.4 3.01
24	σ=0.4 3.54	σ=0.4 3.12	σ=0.4 2.83	σ=0.4 2.51	σ=0.4 2.46	σ=0.4 2.45	σ=0.4 2.44	σ=0.4 2.45	σ=0.4 2.47
23	σ=0.4 3.54	σ=0.4 3.11	σ=0.4 2.81	σ=0.4 2.49	σ=0.4 2.45	σ=0.4 2.44	σ=0.4 2.46	σ=0.4 2.50	σ=0.4 2.56
22	σ=0.4 3.54	σ=0.4 3.11	σ=0.4 2.81	σ=0.4 2.49	σ=0.4 2.46	σ=0.4 2.51	σ=0.4 2.60	σ=0.4 2.71	σ=0.4 2.81
21	σ=0.4 3.54	σ=0.4 3.11	σ=0.4 2.82	σ=0.4 2.52	σ=0.4 2.62	σ=0.4 2.88	σ=0.4 3.12	σ=0.4 3.35	σ=0.4 3.60

Naples (ITA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.25	σ=0.3 3.01	σ=0.3 2.88	σ=0.3 2.68	σ=0.3 2.62	σ=0.3 2.59	σ=0.3 2.54	σ=0.3 2.51	σ=0.3 2.48
24	σ=0.3 3.24	σ=0.3 2.79	σ=0.3 2.47	σ=0.3 1.90	σ=0.3 1.51	σ=0.3 1.40	σ=0.3 1.38	σ=0.3 1.39	σ=0.3 1.42
23	σ=0.3 3.23	σ=0.3 2.78	σ=0.3 2.45	σ=0.3 1.88	σ=0.3 1.49	σ=0.3 1.40	σ=0.3 1.40	σ=0.3 1.44	σ=0.3 1.49
22	σ=0.3 3.23	σ=0.3 2.78	σ=0.3 2.44	σ=0.3 1.88	σ=0.3 1.51	σ=0.3 1.48	σ=0.3 1.55	σ=0.3 1.66	σ=0.3 1.78
21	σ=0.3 3.23	σ=0.3 2.79	σ=0.3 2.46	σ=0.2 1.92	σ=0.3 1.71	σ=0.3 1.87	σ=0.3 2.13	σ=0.3 2.43	σ=0.3 2.75

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.25	σ=0.3 3.00	σ=0.3 2.87	σ=0.3 2.70	σ=0.3 2.69	σ=0.3 2.67	σ=0.3 2.60	σ=0.3 2.55	σ=0.3 2.51
24	σ=0.3 3.23	σ=0.3 2.79	σ=0.3 2.47	σ=0.3 1.95	σ=0.3 1.66	σ=0.3 1.64	σ=0.3 1.64	σ=0.3 1.65	σ=0.3 1.66
23	σ=0.3 3.23	σ=0.3 2.77	σ=0.3 2.45	σ=0.3 1.93	σ=0.3 1.64	σ=0.3 1.63	σ=0.3 1.67	σ=0.3 1.70	σ=0.3 1.74
22	σ=0.3 3.23	σ=0.3 2.77	σ=0.3 2.44	σ=0.3 1.92	σ=0.3 1.66	σ=0.3 1.71	σ=0.3 1.81	σ=0.3 1.91	σ=0.3 2.02
21	σ=0.3 3.23	σ=0.3 2.78	σ=0.3 2.45	σ=0.3 1.96	σ=0.3 1.86	σ=0.3 2.10	σ=0.3 2.38	σ=0.3 2.68	σ=0.3 3.00

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.24	σ=0.3 3.00	σ=0.3 2.89	σ=0.3 2.80	σ=0.3 2.81	σ=0.3 2.74	σ=0.3 2.68	σ=0.3 2.63	σ=0.3 2.60
24	σ=0.3 3.23	σ=0.3 2.78	σ=0.3 2.49	σ=0.3 2.10	σ=0.3 1.98	σ=0.3 1.97	σ=0.3 1.97	σ=0.3 1.98	σ=0.3 1.99
23	σ=0.3 3.22	σ=0.3 2.77	σ=0.3 2.47	σ=0.3 2.08	σ=0.3 1.96	σ=0.3 1.97	σ=0.3 1.99	σ=0.3 2.03	σ=0.3 2.07
22	σ=0.3 3.22	σ=0.3 2.77	σ=0.3 2.47	σ=0.3 2.07	σ=0.3 1.98	σ=0.3 2.04	σ=0.3 2.13	σ=0.3 2.23	σ=0.3 2.35
21	σ=0.3 3.23	σ=0.3 2.78	σ=0.3 2.48	σ=0.3 2.11	σ=0.3 2.18	σ=0.3 2.43	σ=0.3 2.70	σ=0.3 2.99	σ=0.4 3.31

Valencia (ESP)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.91	σ=0.2 2.68	σ=0.2 2.54	σ=0.2 2.41	σ=0.2 2.35	σ=0.2 2.32	σ=0.2 2.29	σ=0.2 2.26	σ=0.2 2.24
24	σ=0.3 2.89	σ=0.2 2.47	σ=0.2 2.14	σ=0.2 1.63	σ=0.2 1.31	σ=0.2 1.21	σ=0.2 1.19	σ=0.2 1.20	σ=0.2 1.22
23	σ=0.3 2.89	σ=0.2 2.45	σ=0.2 2.13	σ=0.2 1.61	σ=0.2 1.29	σ=0.2 1.21	σ=0.2 1.21	σ=0.2 1.25	σ=0.2 1.31
22	σ=0.3 2.88	σ=0.2 2.44	σ=0.2 2.12	σ=0.2 1.61	σ=0.2 1.32	σ=0.2 1.29	σ=0.2 1.36	σ=0.2 1.49	σ=0.2 1.62
21	σ=0.3 2.89	σ=0.2 2.45	σ=0.2 2.14	σ=0.2 1.66	σ=0.2 1.53	σ=0.2 1.72	σ=0.2 2.02	σ=0.3 2.37	σ=0.3 2.75

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.90	σ=0.2 2.66	σ=0.2 2.52	σ=0.2 2.43	σ=0.2 2.44	σ=0.2 2.41	σ=0.2 2.35	σ=0.2 2.30	σ=0.2 2.27
24	σ=0.3 2.88	σ=0.2 2.45	σ=0.2 2.13	σ=0.2 1.67	σ=0.2 1.45	σ=0.2 1.44	σ=0.2 1.44	σ=0.2 1.44	σ=0.2 1.45
23	σ=0.3 2.88	σ=0.2 2.43	σ=0.2 2.11	σ=0.2 1.65	σ=0.2 1.44	σ=0.2 1.44	σ=0.2 1.46	σ=0.2 1.49	σ=0.2 1.54
22	σ=0.3 2.88	σ=0.2 2.43	σ=0.2 2.11	σ=0.2 1.65	σ=0.2 1.46	σ=0.2 1.52	σ=0.2 1.62	σ=0.2 1.73	σ=0.2 1.86
21	σ=0.3 2.88	σ=0.2 2.43	σ=0.2 2.12	σ=0.2 1.69	σ=0.2 1.67	σ=0.2 1.96	σ=0.3 2.28	σ=0.3 2.62	σ=0.3 2.98

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.90	σ=0.2 2.66	σ=0.2 2.54	σ=0.2 2.51	σ=0.2 2.52	σ=0.2 2.46	σ=0.2 2.41	σ=0.2 2.37	σ=0.2 2.34
24	σ=0.3 2.88	σ=0.2 2.45	σ=0.2 2.15	σ=0.2 1.79	σ=0.3 1.70	σ=0.2 1.69	σ=0.2 1.68	σ=0.2 1.69	σ=0.2 1.69
23	σ=0.3 2.87	σ=0.2 2.43	σ=0.2 2.14	σ=0.2 1.77	σ=0.2 1.69	σ=0.2 1.69	σ=0.2 1.71	σ=0.2 1.74	σ=0.2 1.78
22	σ=0.3 2.87	σ=0.2 2.43	σ=0.2 2.14	σ=0.2 1.77	σ=0.2 1.71	σ=0.2 1.77	σ=0.2 1.87	σ=0.2 1.98	σ=0.2 2.11
21	σ=0.3 2.87	σ=0.2 2.44	σ=0.2 2.15	σ=0.2 1.82	σ=0.2 1.92	σ=0.2 2.20	σ=0.3 2.52	σ=0.3 2.86	σ=0.3 3.23

Izmir (TUR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.47	σ=0.3 3.14	σ=0.3 2.94	σ=0.3 2.80	σ=0.3 2.75	σ=0.3 2.70	σ=0.3 2.66	σ=0.3 2.62	σ=0.3 2.58
24	σ=0.3 3.45	σ=0.3 2.95	σ=0.3 2.49	σ=0.3 1.84	σ=0.3 1.55	σ=0.3 1.46	σ=0.3 1.44	σ=0.3 1.45	σ=0.3 1.47
23	σ=0.3 3.45	σ=0.3 2.94	σ=0.3 2.48	σ=0.3 1.81	σ=0.3 1.52	σ=0.3 1.45	σ=0.3 1.46	σ=0.3 1.50	σ=0.3 1.55
22	σ=0.3 3.45	σ=0.3 2.94	σ=0.3 2.48	σ=0.3 1.80	σ=0.3 1.53	σ=0.3 1.54	σ=0.3 1.61	σ=0.3 1.72	σ=0.3 1.84
21	σ=0.3 3.45	σ=0.3 2.95	σ=0.3 2.49	σ=0.3 1.85	σ=0.3 1.75	σ=0.3 1.94	σ=0.3 2.21	σ=0.3 2.52	σ=0.4 2.86

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.46	σ=0.3 3.13	σ=0.3 2.95	σ=0.3 2.84	σ=0.3 2.84	σ=0.3 2.80	σ=0.3 2.74	σ=0.3 2.68	σ=0.3 2.63
24	σ=0.3 3.45	σ=0.3 2.95	σ=0.3 2.50	σ=0.3 1.90	σ=0.3 1.66	σ=0.3 1.63	σ=0.3 1.64	σ=0.3 1.65	σ=0.3 1.66
23	σ=0.3 3.45	σ=0.3 2.94	σ=0.3 2.49	σ=0.3 1.86	σ=0.3 1.63	σ=0.3 1.62	σ=0.3 1.66	σ=0.3 1.70	σ=0.3 1.74
22	σ=0.3 3.45	σ=0.3 2.94	σ=0.3 2.49	σ=0.3 1.86	σ=0.3 1.65	σ=0.3 1.71	σ=0.3 1.80	σ=0.3 1.91	σ=0.3 2.03
21	σ=0.3 3.45	σ=0.3 2.95	σ=0.3 2.50	σ=0.3 1.90	σ=0.3 1.87	σ=0.3 2.11	σ=0.3 2.40	σ=0.3 2.71	σ=0.4 3.05

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.46	σ=0.3 3.14	σ=0.3 2.98	σ=0.3 2.94	σ=0.3 2.96	σ=0.3 2.88	σ=0.3 2.80	σ=0.3 2.75	σ=0.3 2.71
24	σ=0.3 3.45	σ=0.3 2.96	σ=0.3 2.55	σ=0.3 2.02	σ=0.3 1.89	σ=0.3 1.88	σ=0.3 1.88	σ=0.3 1.89	σ=0.3 1.90
23	σ=0.3 3.45	σ=0.3 2.96	σ=0.3 2.53	σ=0.3 1.99	σ=0.3 1.86	σ=0.3 1.87	σ=0.3 1.90	σ=0.3 1.93	σ=0.3 1.98
22	σ=0.3 3.45	σ=0.3 2.96	σ=0.3 2.53	σ=0.3 1.98	σ=0.3 1.88	σ=0.3 1.95	σ=0.3 2.04	σ=0.3 2.14	σ=0.3 2.26
21	σ=0.3 3.45	σ=0.3 2.96	σ=0.3 2.55	σ=0.3 2.03	σ=0.3 2.10	σ=0.3 2.36	σ=0.3 2.63	σ=0.3 2.94	σ=0.4 3.28

Athens (GRC)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.54	σ=0.3 3.30	σ=0.3 3.17	σ=0.3 3.01	σ=0.3 2.91	σ=0.3 2.88	σ=0.3 2.87	σ=0.3 2.86	σ=0.3 2.85
24	σ=0.3 3.52	σ=0.3 3.13	σ=0.3 2.85	σ=0.3 2.43	σ=0.3 2.12	σ=0.3 1.98	σ=0.3 1.92	σ=0.3 1.92	σ=0.3 1.94
23	σ=0.3 3.52	σ=0.3 3.12	σ=0.3 2.84	σ=0.3 2.42	σ=0.3 2.11	σ=0.3 1.98	σ=0.3 1.94	σ=0.3 1.96	σ=0.3 2.01
22	σ=0.3 3.52	σ=0.3 3.12	σ=0.3 2.84	σ=0.3 2.42	σ=0.3 2.13	σ=0.3 2.05	σ=0.3 2.07	σ=0.3 2.15	σ=0.3 2.26
21	σ=0.3 3.52	σ=0.3 3.13	σ=0.3 2.85	σ=0.3 2.46	σ=0.3 2.29	σ=0.3 2.39	σ=0.3 2.58	σ=0.3 2.84	σ=0.3 3.13

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.53	σ=0.3 3.28	σ=0.3 3.17	σ=0.3 3.07	σ=0.3 3.05	σ=0.3 3.04	σ=0.3 3.01	σ=0.3 2.96	σ=0.3 2.94
24	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.85	σ=0.3 2.51	σ=0.3 2.33	σ=0.3 2.31	σ=0.3 2.31	σ=0.3 2.31	σ=0.3 2.31
23	σ=0.3 3.51	σ=0.3 3.10	σ=0.3 2.84	σ=0.3 2.50	σ=0.3 2.32	σ=0.3 2.30	σ=0.3 2.33	σ=0.3 2.35	σ=0.3 2.38
22	σ=0.3 3.51	σ=0.3 3.10	σ=0.3 2.84	σ=0.3 2.50	σ=0.3 2.34	σ=0.3 2.37	σ=0.3 2.46	σ=0.3 2.54	σ=0.3 2.63
21	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.85	σ=0.3 2.53	σ=0.3 2.50	σ=0.3 2.71	σ=0.3 2.96	σ=0.3 3.22	σ=0.4 3.49

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.53	σ=0.3 3.28	σ=0.3 3.20	σ=0.3 3.17	σ=0.3 3.17	σ=0.3 3.13	σ=0.3 3.09	σ=0.3 3.06	σ=0.3 3.03
24	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.89	σ=0.3 2.65	σ=0.3 2.58	σ=0.3 2.57	σ=0.3 2.56	σ=0.3 2.57	σ=0.3 2.57
23	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.88	σ=0.3 2.64	σ=0.3 2.57	σ=0.3 2.57	σ=0.3 2.59	σ=0.3 2.61	σ=0.3 2.64
22	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.88	σ=0.3 2.64	σ=0.3 2.59	σ=0.3 2.64	σ=0.3 2.72	σ=0.3 2.80	σ=0.3 2.89
21	σ=0.3 3.51	σ=0.3 3.11	σ=0.3 2.89	σ=0.3 2.67	σ=0.3 2.75	σ=0.3 2.97	σ=0.3 3.21	σ=0.4 3.47	σ=0.4 3.75

ACH

Fig. 2. Total air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT) for different climate locations (part 1/2). Cells with redder backgrounds indicate higher heating energy than cooling energy consumption; bluer backgrounds indicate higher cooling energy than heating energy consumption; and whiter backgrounds represent balanced consumption between heating and cooling demand (with white denoting the middle point). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.

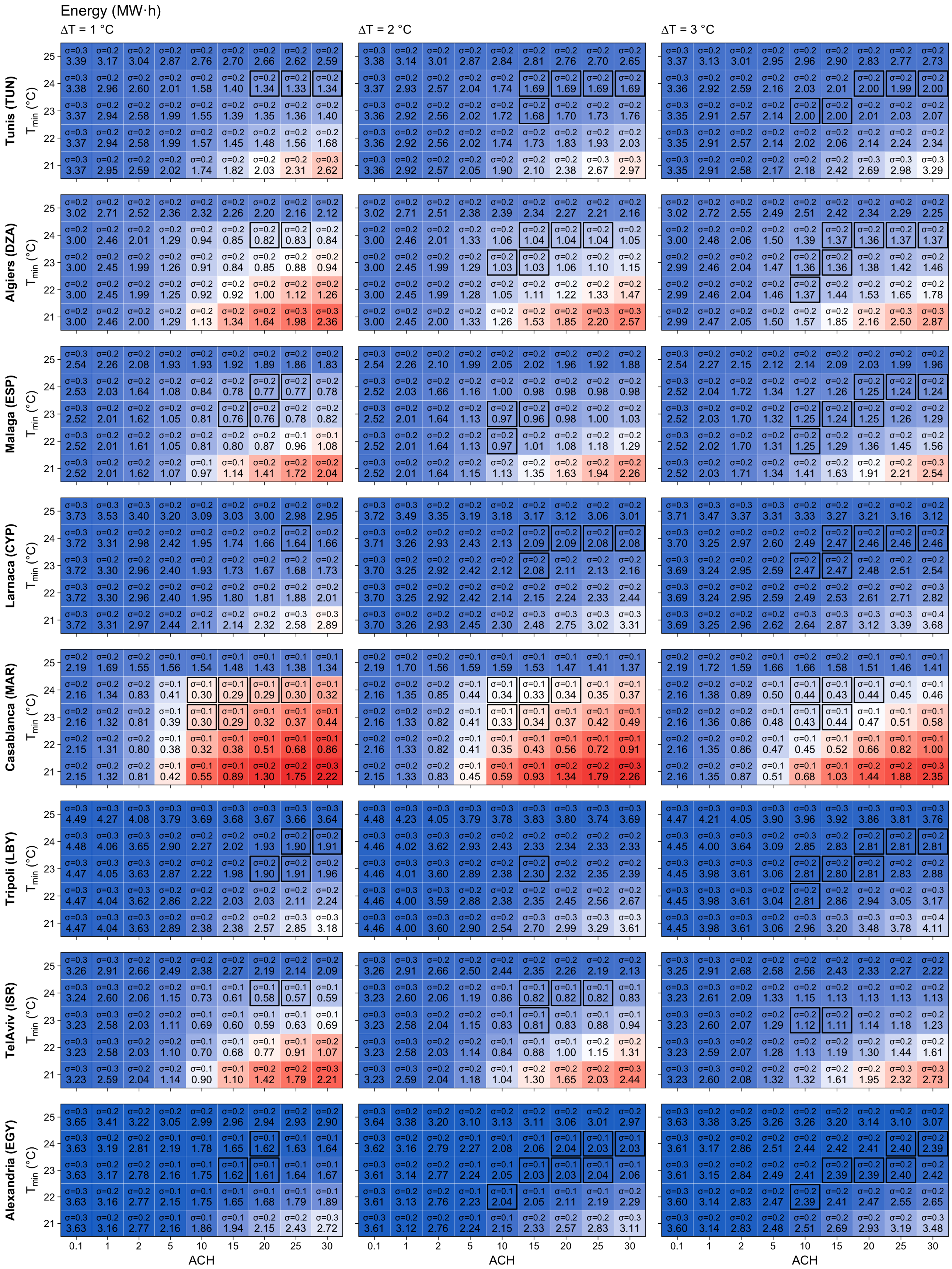


Fig. 3. Total air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT) for different climate locations (part 2/2). Cells with redder backgrounds indicate higher heating energy than cooling energy consumption; bluer backgrounds indicate higher cooling energy than heating energy consumption; and whiter backgrounds represent balanced consumption between heating and cooling demand (with white denoting the middle point). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.

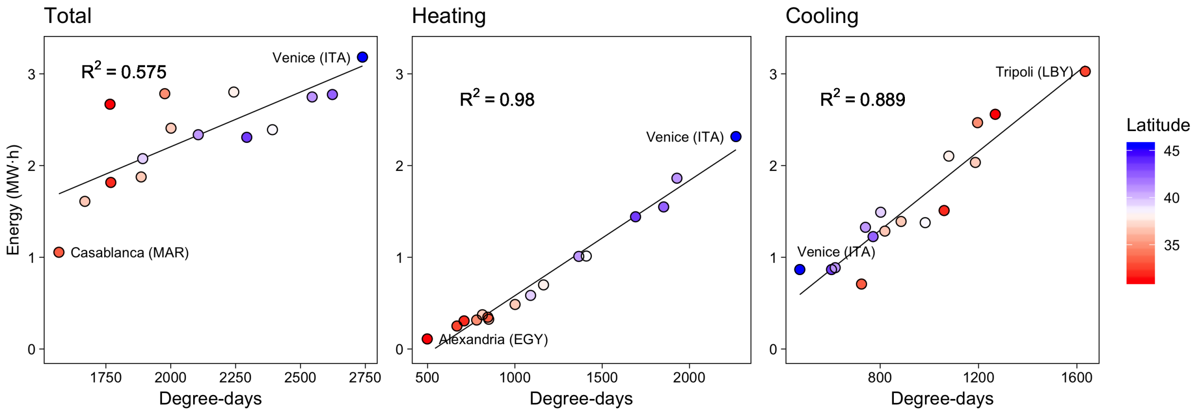
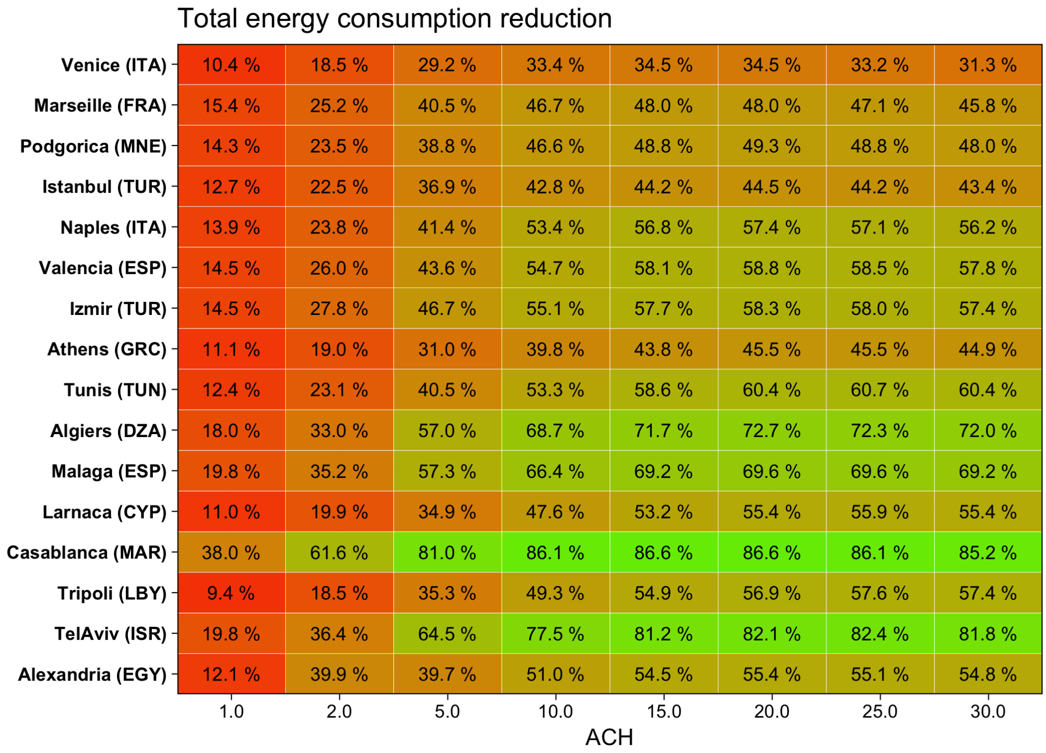


Fig. 4. Correlation of the average energy consumption for air-conditioning and the degree-days for the different Mediterranean locations. Energy consumption corresponds to the average result for all ACH, T_{min} and ΔT values considered in this study.

the highest reduction values in energy consumption along the ACH scale. Above 10 ACH the results tend to stabilize for all locations, which is in line with the findings presented by Finn et al. [31]: a ventilation rate up to 10 ACH has a significant effect on the reduction of temperature, but further increases of air changes have a negligent effect.



Total energy consumption reduction

ACH	1.0	2.0	5.0	10.0	15.0	20.0	25.0	30.0
Venice (ITA)	10.4 %	18.5 %	29.2 %	33.4 %	34.5 %	34.5 %	33.2 %	31.3 %
Marseille (FRA)	15.4 %	25.2 %	40.5 %	46.7 %	48.0 %	48.0 %	47.1 %	45.8 %
Podgorica (MNE)	14.3 %	23.5 %	38.8 %	46.6 %	48.8 %	49.3 %	48.8 %	48.0 %
Istanbul (TUR)	12.7 %	22.5 %	36.9 %	42.8 %	44.2 %	44.5 %	44.2 %	43.4 %
Naples (ITA)	13.9 %	23.8 %	41.4 %	53.4 %	56.8 %	57.4 %	57.1 %	56.2 %
Valencia (ESP)	14.5 %	26.0 %	43.6 %	54.7 %	58.1 %	58.8 %	58.5 %	57.8 %
Izmir (TUR)	14.5 %	27.8 %	46.7 %	55.1 %	57.7 %	58.3 %	58.0 %	57.4 %
Athens (GRC)	11.1 %	19.0 %	31.0 %	39.8 %	43.8 %	45.5 %	45.5 %	44.9 %
Tunis (TUN)	12.4 %	23.1 %	40.5 %	53.3 %	58.6 %	60.4 %	60.7 %	60.4 %
Algiers (DZA)	18.0 %	33.0 %	57.0 %	68.7 %	71.7 %	72.7 %	72.3 %	72.0 %
Malaga (ESP)	19.8 %	35.2 %	57.3 %	66.4 %	69.2 %	69.6 %	69.6 %	69.2 %
Larnaca (CYP)	11.0 %	19.9 %	34.9 %	47.6 %	53.2 %	55.4 %	55.9 %	55.4 %
Casablanca (MAR)	38.0 %	61.6 %	81.0 %	86.1 %	86.6 %	86.6 %	86.1 %	85.2 %
Tripoli (LBY)	9.4 %	18.5 %	35.3 %	49.3 %	54.9 %	56.9 %	57.6 %	57.4 %
TelAviv (ISR)	19.8 %	36.4 %	64.5 %	77.5 %	81.2 %	82.1 %	82.4 %	81.8 %
Alexandria (EGY)	12.1 %	39.9 %	39.7 %	51.0 %	54.5 %	55.4 %	55.1 %	54.8 %

Fig. 5. Total energy consumption reduction in relation to 0.1 ACH, considering $T_{min} = 24\,°C$ and $\Delta T = 1\,°C$.

4. Conclusion

In this study, the energy performance of a large group of randomly generated buildings was evaluated for a set of ventilation parameters – air change rate and ventilation setpoint temperatures – in sixteen Mediterranean locations. The statistical assessment of this dataset allowed to determine the impact of the ventilation parameters on the energy performance of the buildings, thus making it possible to determine the most adequate set of parameters.

The results demonstrate that the most adequate ventilation specifications (which minimize overall air-conditioning energy consumption) fall within similar values for all the assessed locations: ventilation rates of at least 10 ACH, a T_{min} value slightly below the cooling setpoint, and a low ΔT value. Regarding the ventilation rate, the results are in agreement with the findings of other studies, which point to 10 ACH as the threshold above which the ventilation cooling effect tends to stabilize. Where no active ventilation occurs, the cooling process is likely to be dominated by free convection, and thus significant performance improvement is evident even with modest levels of active ventilation. Further increases in ventilation rate may only result in a relatively small increase in forced convection. It can thus be concluded that even low ACH values ensure a significant increase in energy performance, reaching full potential with moderate ACH values (there is thus no need for very high ventilation rates). In relation to T_{min}, a significant performance increase is obtainable when initiating ventilation 1 °C below the cooling setpoint. Above this threshold the results tend to stabilize, meaning that there is no advantage in increasing the over-cooling effect. As for the ΔT, the lowest value leads to the best performances, indicating that ventilation should be able to occur as soon as the outdoor conditions allow, in order to rapidly promote the ventilation cooling effect. On the other hand, the combination of temperature setpoint values (T_{min} and ΔT) considered in this study allows the ventilation to occur without any restrictions other than the indoor and outdoor temperature limitations, thus not restricting this study to a specific context (*e.g.*, night ventilation). This, together with the wide range of ACH values assessed, makes this study more comprehensive: its results can be useful in different contexts (*e.g.*, free cooling or mechanical ventilation), thus helping to evaluate the best solution for each case.

The results also show that, in lower latitudes, lower energy consumptions lead to smaller ranges in performance between buildings, indicating that if the ventilation specifications allow for a high energy performance, the geometry and orientation of the building influence performance to a lesser extent. This implies that as long as buildings in the warmer southern Mediterranean region present efficient ventilation strategies, their shape and orientation have no significant impact on energy performance, making ventilation the key parameter for this region. It was also found that there is no direct correlation between the variations in energy consumption and the buildings' latitude, apart from the tendency for heating consumption to decrease for lower latitudes. However, heating and cooling energy consumptions reveal very strong correlations with the heating and cooling degree-days, respectively, for each location.

It can be concluded that ventilation has the most beneficial contribution to energy performance when used as soon as the exterior conditions are favorable (the lower ΔT value possible), when the indoor air is renewed with a moderate flow rate (at least 10 ACH), and while inducing a slight over-cooling (slightly under the cooling setpoint), so that the cooling demand is reduced without excessively penalizing the heating consumption.

By considering a large group of randomly generated buildings, this study presents a novel approach that prevents the potential bias that may result from using a single or limited type of building geometry in a specific climatic location to evaluate the effects of different ventilation specifications on energy performance. The results allow building practitioners to infer the most adequate actions regarding ventilation strategies and controls to implement. In addition, the results may be used as indicative values in the early stages of building design or to improve the search speed of optimization procedures. However, it should be pointed out that these results are dependent on the studied building types, occupants' behaviors, and ventilation parameters and respective ranges. Therefore, further studies should complement the present results by analyzing other types of buildings in other operation scenarios.

Data availability

The dataset related to buildings located in the sixteen locations in the Mediterranean can be found at URL `https://bit.ly/2U3APwC`, hosted at figshare ([30]).

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Declarations of interest: none.

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AppendixA. Heating and cooling energy consumption

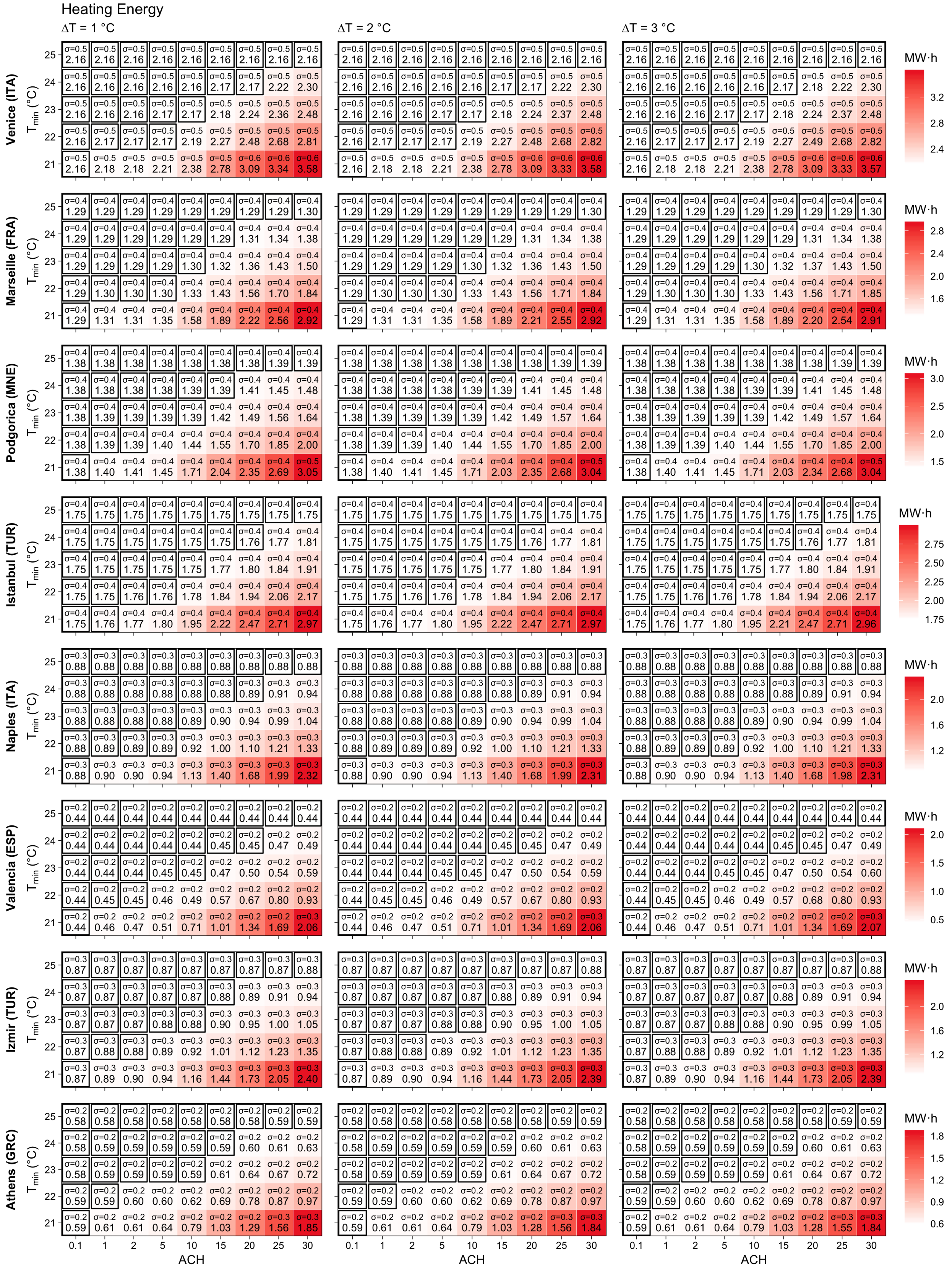


Fig. A.1. Heating air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT), for different climate locations (part 1/2). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.

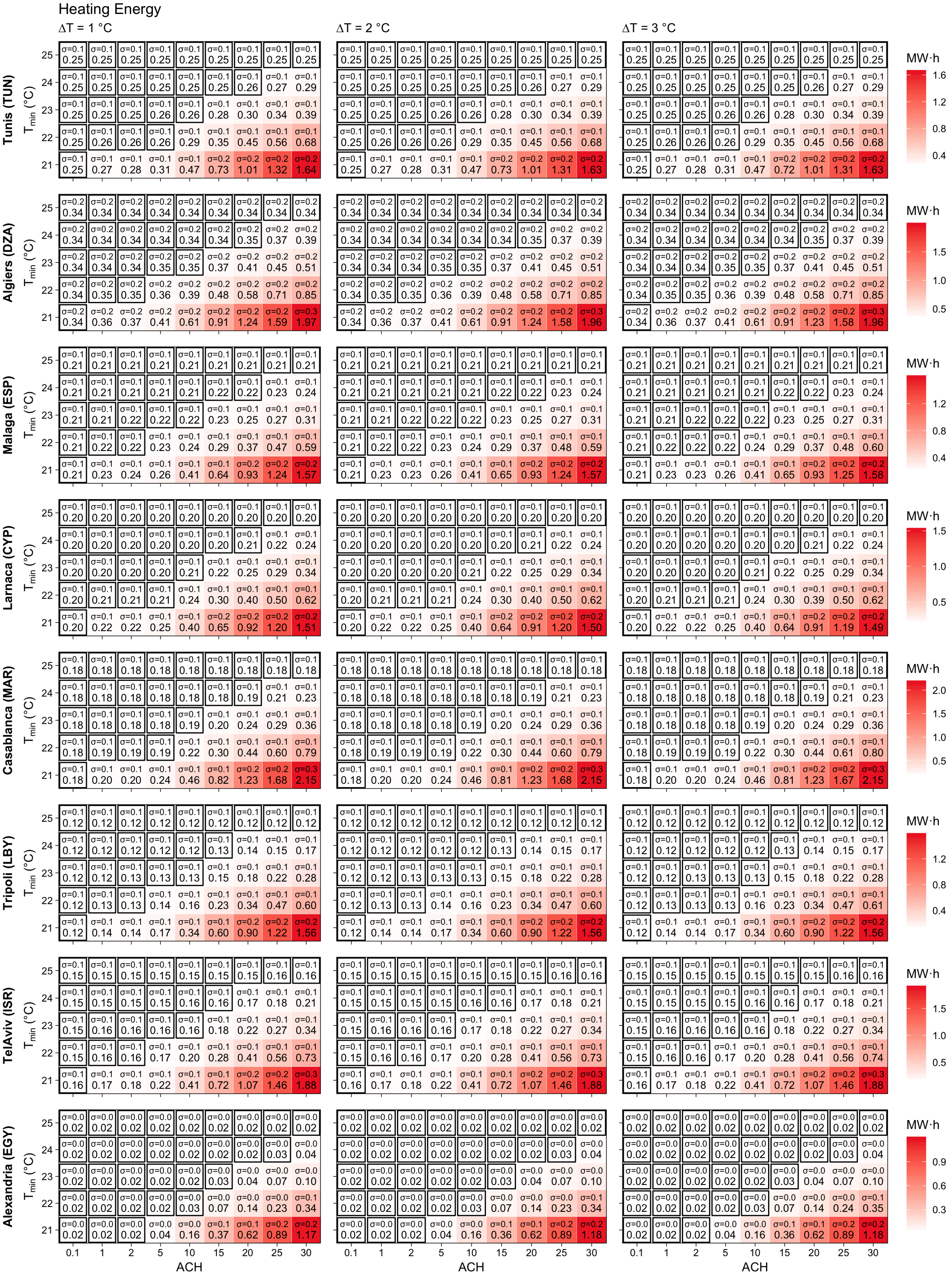
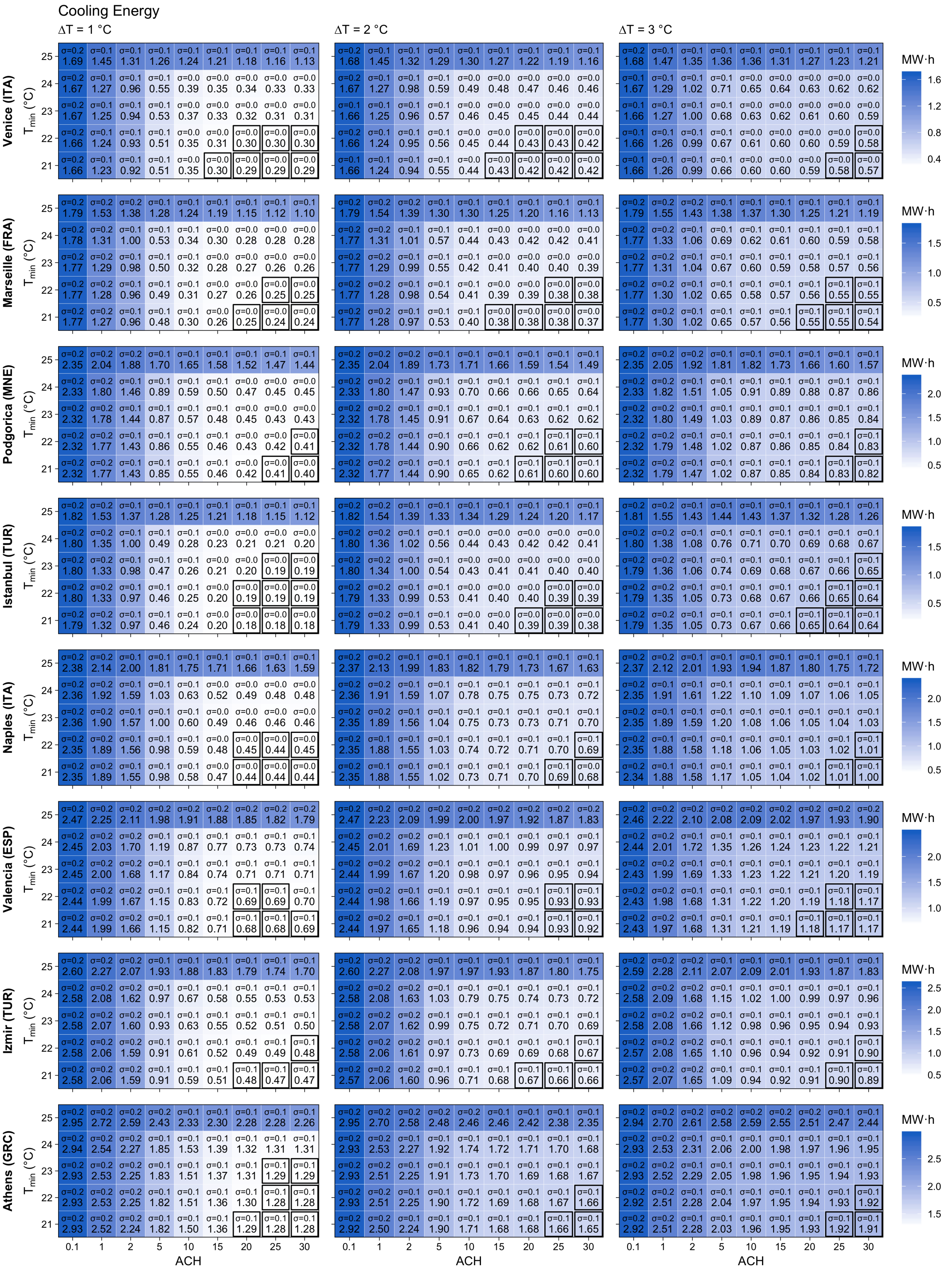


Fig. A.2. Heating air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT), for different climate locations (part 2/2). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.



Venice (ITA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.69	σ=0.1 1.45	σ=0.1 1.31	σ=0.1 1.26	σ=0.1 1.24	σ=0.1 1.21	σ=0.1 1.18	σ=0.1 1.16	σ=0.1 1.13
24	σ=0.2 1.67	σ=0.1 1.27	σ=0.1 0.96	σ=0.1 0.55	σ=0.0 0.39	σ=0.0 0.35	σ=0.0 0.34	σ=0.0 0.33	σ=0.0 0.33
23	σ=0.2 1.67	σ=0.1 1.25	σ=0.1 0.94	σ=0.1 0.53	σ=0.0 0.37	σ=0.0 0.33	σ=0.0 0.32	σ=0.0 0.31	σ=0.0 0.31
22	σ=0.2 1.66	σ=0.1 1.24	σ=0.1 0.93	σ=0.1 0.51	σ=0.0 0.35	σ=0.0 0.31	σ=0.0 0.30	σ=0.0 0.30	σ=0.0 0.30
21	σ=0.2 1.66	σ=0.1 1.23	σ=0.1 0.92	σ=0.1 0.51	σ=0.0 0.35	σ=0.0 0.30	σ=0.0 0.29	σ=0.0 0.29	σ=0.0 0.29

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.68	σ=0.1 1.45	σ=0.1 1.32	σ=0.1 1.29	σ=0.1 1.30	σ=0.1 1.27	σ=0.1 1.22	σ=0.1 1.19	σ=0.1 1.16
24	σ=0.2 1.67	σ=0.1 1.27	σ=0.1 0.98	σ=0.1 0.59	σ=0.0 0.49	σ=0.0 0.48	σ=0.0 0.47	σ=0.0 0.46	σ=0.0 0.46
23	σ=0.1 1.66	σ=0.1 1.25	σ=0.1 0.96	σ=0.1 0.57	σ=0.0 0.46	σ=0.0 0.45	σ=0.0 0.45	σ=0.0 0.44	σ=0.0 0.44
22	σ=0.2 1.66	σ=0.1 1.24	σ=0.1 0.95	σ=0.1 0.56	σ=0.0 0.45	σ=0.0 0.44	σ=0.0 0.43	σ=0.0 0.43	σ=0.0 0.42
21	σ=0.1 1.66	σ=0.1 1.24	σ=0.1 0.94	σ=0.1 0.55	σ=0.0 0.44	σ=0.0 0.43	σ=0.0 0.42	σ=0.0 0.42	σ=0.0 0.42

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.68	σ=0.1 1.47	σ=0.1 1.35	σ=0.1 1.36	σ=0.1 1.36	σ=0.1 1.31	σ=0.1 1.27	σ=0.1 1.23	σ=0.1 1.21
24	σ=0.1 1.67	σ=0.1 1.29	σ=0.1 1.02	σ=0.1 0.71	σ=0.0 0.65	σ=0.0 0.64	σ=0.0 0.63	σ=0.0 0.62	σ=0.0 0.62
23	σ=0.1 1.66	σ=0.1 1.27	σ=0.1 1.00	σ=0.1 0.68	σ=0.0 0.63	σ=0.0 0.62	σ=0.0 0.61	σ=0.0 0.60	σ=0.0 0.59
22	σ=0.1 1.66	σ=0.1 1.26	σ=0.1 0.99	σ=0.1 0.67	σ=0.0 0.61	σ=0.0 0.60	σ=0.0 0.60	σ=0.0 0.59	σ=0.0 0.58
21	σ=0.1 1.66	σ=0.1 1.26	σ=0.1 0.99	σ=0.1 0.66	σ=0.0 0.60	σ=0.0 0.60	σ=0.0 0.59	σ=0.0 0.58	σ=0.0 0.57

Marseille (FRA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.79	σ=0.2 1.53	σ=0.2 1.38	σ=0.1 1.28	σ=0.1 1.24	σ=0.1 1.19	σ=0.1 1.15	σ=0.1 1.12	σ=0.1 1.10
24	σ=0.2 1.78	σ=0.2 1.31	σ=0.1 1.00	σ=0.1 0.53	σ=0.1 0.34	σ=0.0 0.30	σ=0.0 0.28	σ=0.0 0.28	σ=0.0 0.28
23	σ=0.2 1.77	σ=0.2 1.29	σ=0.1 0.98	σ=0.1 0.50	σ=0.1 0.32	σ=0.0 0.28	σ=0.0 0.27	σ=0.0 0.26	σ=0.0 0.26
22	σ=0.2 1.77	σ=0.2 1.28	σ=0.1 0.96	σ=0.1 0.49	σ=0.1 0.31	σ=0.1 0.27	σ=0.0 0.26	σ=0.0 0.25	σ=0.0 0.25
21	σ=0.2 1.77	σ=0.2 1.27	σ=0.1 0.96	σ=0.1 0.48	σ=0.1 0.30	σ=0.0 0.26	σ=0.0 0.25	σ=0.0 0.24	σ=0.0 0.24

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.79	σ=0.2 1.54	σ=0.2 1.39	σ=0.1 1.30	σ=0.1 1.30	σ=0.1 1.25	σ=0.1 1.20	σ=0.1 1.16	σ=0.1 1.13
24	σ=0.2 1.77	σ=0.2 1.31	σ=0.1 1.01	σ=0.1 0.57	σ=0.1 0.44	σ=0.0 0.43	σ=0.0 0.42	σ=0.0 0.42	σ=0.0 0.41
23	σ=0.2 1.77	σ=0.2 1.29	σ=0.1 0.99	σ=0.1 0.55	σ=0.1 0.42	σ=0.1 0.41	σ=0.0 0.40	σ=0.0 0.40	σ=0.0 0.39
22	σ=0.2 1.77	σ=0.2 1.28	σ=0.1 0.98	σ=0.1 0.54	σ=0.1 0.41	σ=0.0 0.39	σ=0.0 0.39	σ=0.0 0.38	σ=0.0 0.38
21	σ=0.2 1.77	σ=0.2 1.28	σ=0.1 0.97	σ=0.1 0.53	σ=0.1 0.40	σ=0.0 0.38	σ=0.0 0.38	σ=0.0 0.38	σ=0.0 0.37

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.79	σ=0.2 1.55	σ=0.2 1.43	σ=0.1 1.38	σ=0.1 1.37	σ=0.1 1.30	σ=0.1 1.25	σ=0.1 1.21	σ=0.1 1.19
24	σ=0.2 1.77	σ=0.2 1.33	σ=0.1 1.06	σ=0.1 0.69	σ=0.1 0.62	σ=0.1 0.61	σ=0.1 0.60	σ=0.1 0.59	σ=0.1 0.58
23	σ=0.2 1.77	σ=0.2 1.31	σ=0.1 1.04	σ=0.1 0.67	σ=0.1 0.60	σ=0.1 0.59	σ=0.1 0.58	σ=0.1 0.57	σ=0.1 0.56
22	σ=0.2 1.77	σ=0.2 1.30	σ=0.1 1.02	σ=0.1 0.65	σ=0.1 0.58	σ=0.1 0.57	σ=0.1 0.56	σ=0.1 0.55	σ=0.1 0.55
21	σ=0.2 1.77	σ=0.2 1.30	σ=0.1 1.02	σ=0.1 0.65	σ=0.1 0.57	σ=0.1 0.56	σ=0.1 0.55	σ=0.1 0.55	σ=0.1 0.54

Podgorica (MNE)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.35	σ=0.2 2.04	σ=0.2 1.88	σ=0.1 1.70	σ=0.1 1.65	σ=0.1 1.58	σ=0.1 1.52	σ=0.1 1.47	σ=0.1 1.44
24	σ=0.2 2.33	σ=0.2 1.80	σ=0.1 1.46	σ=0.1 0.89	σ=0.1 0.59	σ=0.1 0.50	σ=0.0 0.47	σ=0.0 0.45	σ=0.0 0.45
23	σ=0.2 2.32	σ=0.2 1.78	σ=0.1 1.44	σ=0.1 0.87	σ=0.1 0.57	σ=0.1 0.48	σ=0.0 0.45	σ=0.0 0.43	σ=0.0 0.43
22	σ=0.2 2.32	σ=0.2 1.77	σ=0.1 1.43	σ=0.1 0.86	σ=0.1 0.55	σ=0.1 0.46	σ=0.0 0.43	σ=0.0 0.42	σ=0.0 0.41
21	σ=0.2 2.32	σ=0.2 1.77	σ=0.1 1.43	σ=0.1 0.85	σ=0.1 0.55	σ=0.1 0.46	σ=0.0 0.42	σ=0.0 0.41	σ=0.0 0.40

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.35	σ=0.2 2.04	σ=0.2 1.89	σ=0.1 1.73	σ=0.1 1.71	σ=0.1 1.66	σ=0.1 1.59	σ=0.1 1.54	σ=0.1 1.49
24	σ=0.2 2.33	σ=0.2 1.80	σ=0.1 1.47	σ=0.1 0.93	σ=0.1 0.70	σ=0.1 0.66	σ=0.1 0.66	σ=0.1 0.65	σ=0.1 0.64
23	σ=0.2 2.32	σ=0.2 1.78	σ=0.1 1.45	σ=0.1 0.91	σ=0.1 0.67	σ=0.1 0.64	σ=0.1 0.63	σ=0.1 0.62	σ=0.1 0.62
22	σ=0.2 2.32	σ=0.2 1.78	σ=0.1 1.44	σ=0.1 0.90	σ=0.1 0.66	σ=0.1 0.62	σ=0.1 0.62	σ=0.1 0.61	σ=0.1 0.60
21	σ=0.2 2.32	σ=0.2 1.77	σ=0.1 1.44	σ=0.1 0.90	σ=0.1 0.65	σ=0.1 0.62	σ=0.1 0.61	σ=0.1 0.60	σ=0.1 0.60

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.35	σ=0.2 2.05	σ=0.2 1.92	σ=0.1 1.81	σ=0.1 1.82	σ=0.1 1.73	σ=0.1 1.66	σ=0.1 1.60	σ=0.1 1.57
24	σ=0.2 2.33	σ=0.2 1.82	σ=0.1 1.51	σ=0.1 1.05	σ=0.1 0.91	σ=0.1 0.89	σ=0.1 0.88	σ=0.1 0.87	σ=0.1 0.86
23	σ=0.2 2.32	σ=0.2 1.80	σ=0.1 1.49	σ=0.1 1.03	σ=0.1 0.89	σ=0.1 0.87	σ=0.1 0.86	σ=0.1 0.85	σ=0.1 0.84
22	σ=0.2 2.32	σ=0.2 1.79	σ=0.1 1.48	σ=0.1 1.02	σ=0.1 0.87	σ=0.1 0.86	σ=0.1 0.85	σ=0.1 0.84	σ=0.1 0.83
21	σ=0.2 2.32	σ=0.2 1.79	σ=0.1 1.47	σ=0.1 1.02	σ=0.1 0.87	σ=0.1 0.85	σ=0.1 0.84	σ=0.1 0.83	σ=0.1 0.82

Istanbul (TUR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.82	σ=0.2 1.53	σ=0.1 1.37	σ=0.1 1.28	σ=0.1 1.25	σ=0.1 1.21	σ=0.1 1.18	σ=0.1 1.15	σ=0.1 1.12
24	σ=0.2 1.80	σ=0.2 1.35	σ=0.1 1.00	σ=0.1 0.49	σ=0.1 0.28	σ=0.0 0.23	σ=0.0 0.21	σ=0.0 0.21	σ=0.0 0.20
23	σ=0.2 1.80	σ=0.2 1.33	σ=0.1 0.98	σ=0.1 0.47	σ=0.1 0.26	σ=0.0 0.21	σ=0.0 0.20	σ=0.0 0.19	σ=0.0 0.19
22	σ=0.2 1.80	σ=0.2 1.33	σ=0.1 0.97	σ=0.1 0.46	σ=0.1 0.25	σ=0.0 0.20	σ=0.0 0.19	σ=0.0 0.19	σ=0.0 0.19
21	σ=0.2 1.79	σ=0.2 1.32	σ=0.1 0.97	σ=0.1 0.46	σ=0.1 0.24	σ=0.0 0.20	σ=0.0 0.18	σ=0.0 0.18	σ=0.0 0.18

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.82	σ=0.2 1.54	σ=0.1 1.39	σ=0.1 1.33	σ=0.1 1.34	σ=0.1 1.29	σ=0.1 1.24	σ=0.1 1.20	σ=0.1 1.17
24	σ=0.2 1.80	σ=0.2 1.36	σ=0.1 1.02	σ=0.1 0.56	σ=0.0 0.44	σ=0.0 0.43	σ=0.0 0.42	σ=0.0 0.42	σ=0.0 0.41
23	σ=0.2 1.80	σ=0.2 1.34	σ=0.1 1.00	σ=0.1 0.54	σ=0.0 0.43	σ=0.0 0.41	σ=0.0 0.41	σ=0.0 0.40	σ=0.0 0.40
22	σ=0.2 1.79	σ=0.2 1.33	σ=0.1 0.99	σ=0.1 0.53	σ=0.0 0.41	σ=0.0 0.40	σ=0.0 0.40	σ=0.0 0.39	σ=0.0 0.39
21	σ=0.2 1.79	σ=0.2 1.33	σ=0.1 0.99	σ=0.1 0.53	σ=0.1 0.41	σ=0.0 0.40	σ=0.0 0.39	σ=0.0 0.39	σ=0.0 0.38

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 1.81	σ=0.2 1.55	σ=0.2 1.43	σ=0.1 1.44	σ=0.1 1.43	σ=0.1 1.37	σ=0.1 1.32	σ=0.1 1.28	σ=0.1 1.26
24	σ=0.2 1.80	σ=0.2 1.38	σ=0.1 1.08	σ=0.1 0.76	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.69	σ=0.1 0.68	σ=0.1 0.67
23	σ=0.2 1.79	σ=0.2 1.36	σ=0.1 1.06	σ=0.1 0.74	σ=0.1 0.69	σ=0.1 0.68	σ=0.1 0.67	σ=0.1 0.66	σ=0.1 0.65
22	σ=0.2 1.79	σ=0.2 1.35	σ=0.1 1.05	σ=0.1 0.73	σ=0.1 0.68	σ=0.1 0.67	σ=0.1 0.66	σ=0.1 0.65	σ=0.1 0.64
21	σ=0.2 1.79	σ=0.2 1.35	σ=0.1 1.05	σ=0.1 0.73	σ=0.1 0.67	σ=0.1 0.66	σ=0.1 0.65	σ=0.1 0.64	σ=0.1 0.64

Naples (ITA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.38	σ=0.2 2.14	σ=0.1 2.00	σ=0.1 1.81	σ=0.1 1.75	σ=0.1 1.71	σ=0.1 1.66	σ=0.1 1.63	σ=0.1 1.59
24	σ=0.2 2.36	σ=0.2 1.92	σ=0.1 1.59	σ=0.1 1.03	σ=0.1 0.63	σ=0.0 0.52	σ=0.0 0.49	σ=0.0 0.48	σ=0.0 0.48
23	σ=0.2 2.36	σ=0.2 1.90	σ=0.1 1.57	σ=0.1 1.00	σ=0.1 0.60	σ=0.0 0.49	σ=0.0 0.46	σ=0.0 0.46	σ=0.0 0.46
22	σ=0.2 2.35	σ=0.2 1.89	σ=0.1 1.56	σ=0.1 0.98	σ=0.1 0.59	σ=0.1 0.48	σ=0.0 0.45	σ=0.0 0.44	σ=0.0 0.45
21	σ=0.2 2.35	σ=0.2 1.89	σ=0.1 1.55	σ=0.1 0.98	σ=0.1 0.58	σ=0.0 0.47	σ=0.0 0.44	σ=0.0 0.44	σ=0.0 0.44

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.37	σ=0.2 2.13	σ=0.1 1.99	σ=0.1 1.83	σ=0.1 1.82	σ=0.1 1.79	σ=0.1 1.73	σ=0.1 1.67	σ=0.1 1.63
24	σ=0.2 2.36	σ=0.2 1.91	σ=0.1 1.59	σ=0.1 1.07	σ=0.1 0.78	σ=0.1 0.75	σ=0.1 0.75	σ=0.1 0.73	σ=0.1 0.72
23	σ=0.2 2.35	σ=0.2 1.89	σ=0.1 1.56	σ=0.1 1.04	σ=0.1 0.75	σ=0.1 0.73	σ=0.1 0.73	σ=0.1 0.71	σ=0.1 0.70
22	σ=0.2 2.35	σ=0.1 1.88	σ=0.1 1.55	σ=0.1 1.03	σ=0.1 0.74	σ=0.1 0.72	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.69
21	σ=0.2 2.35	σ=0.1 1.88	σ=0.1 1.55	σ=0.1 1.02	σ=0.1 0.73	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.69	σ=0.0 0.68

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.37	σ=0.2 2.12	σ=0.1 2.01	σ=0.1 1.93	σ=0.1 1.94	σ=0.1 1.87	σ=0.1 1.80	σ=0.1 1.75	σ=0.1 1.72
24	σ=0.2 2.35	σ=0.1 1.91	σ=0.1 1.61	σ=0.1 1.22	σ=0.1 1.10	σ=0.1 1.09	σ=0.1 1.07	σ=0.1 1.06	σ=0.1 1.05
23	σ=0.2 2.35	σ=0.1 1.89	σ=0.1 1.59	σ=0.1 1.20	σ=0.1 1.08	σ=0.1 1.06	σ=0.1 1.05	σ=0.1 1.04	σ=0.1 1.03
22	σ=0.2 2.35	σ=0.1 1.88	σ=0.1 1.58	σ=0.1 1.18	σ=0.1 1.06	σ=0.1 1.05	σ=0.1 1.03	σ=0.1 1.02	σ=0.1 1.01
21	σ=0.2 2.34	σ=0.1 1.88	σ=0.1 1.58	σ=0.1 1.17	σ=0.1 1.05	σ=0.1 1.04	σ=0.1 1.02	σ=0.1 1.01	σ=0.1 1.00

Valencia (ESP)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.47	σ=0.2 2.25	σ=0.2 2.11	σ=0.2 1.98	σ=0.2 1.91	σ=0.2 1.88	σ=0.2 1.85	σ=0.2 1.82	σ=0.2 1.79
24	σ=0.2 2.45	σ=0.2 2.03	σ=0.2 1.70	σ=0.1 1.19	σ=0.1 0.87	σ=0.1 0.77	σ=0.1 0.73	σ=0.1 0.73	σ=0.1 0.74
23	σ=0.2 2.45	σ=0.2 2.00	σ=0.2 1.68	σ=0.1 1.17	σ=0.1 0.84	σ=0.1 0.74	σ=0.1 0.71	σ=0.1 0.71	σ=0.1 0.71
22	σ=0.2 2.44	σ=0.2 1.99	σ=0.2 1.67	σ=0.1 1.15	σ=0.1 0.83	σ=0.1 0.72	σ=0.1 0.69	σ=0.1 0.69	σ=0.1 0.70
21	σ=0.2 2.44	σ=0.2 1.99	σ=0.2 1.66	σ=0.1 1.15	σ=0.1 0.82	σ=0.1 0.71	σ=0.1 0.68	σ=0.1 0.68	σ=0.1 0.69

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.47	σ=0.2 2.23	σ=0.2 2.09	σ=0.2 1.99	σ=0.2 2.00	σ=0.2 1.97	σ=0.2 1.92	σ=0.2 1.87	σ=0.2 1.83
24	σ=0.2 2.45	σ=0.2 2.01	σ=0.2 1.69	σ=0.1 1.23	σ=0.1 1.01	σ=0.1 1.00	σ=0.1 0.99	σ=0.1 0.97	σ=0.1 0.97
23	σ=0.2 2.44	σ=0.2 1.99	σ=0.2 1.67	σ=0.1 1.20	σ=0.1 0.98	σ=0.1 0.97	σ=0.1 0.96	σ=0.1 0.95	σ=0.1 0.94
22	σ=0.2 2.44	σ=0.2 1.98	σ=0.2 1.66	σ=0.1 1.19	σ=0.1 0.97	σ=0.1 0.95	σ=0.1 0.95	σ=0.1 0.93	σ=0.1 0.93
21	σ=0.2 2.44	σ=0.2 1.97	σ=0.1 1.65	σ=0.1 1.18	σ=0.1 0.96	σ=0.1 0.94	σ=0.1 0.94	σ=0.1 0.93	σ=0.1 0.92

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.46	σ=0.2 2.22	σ=0.2 2.10	σ=0.2 2.08	σ=0.2 2.09	σ=0.2 2.02	σ=0.2 1.97	σ=0.2 1.93	σ=0.2 1.90
24	σ=0.2 2.44	σ=0.2 2.01	σ=0.2 1.72	σ=0.1 1.35	σ=0.1 1.26	σ=0.1 1.24	σ=0.1 1.23	σ=0.1 1.22	σ=0.1 1.21
23	σ=0.2 2.43	σ=0.2 1.99	σ=0.2 1.69	σ=0.1 1.33	σ=0.1 1.23	σ=0.1 1.22	σ=0.1 1.21	σ=0.1 1.20	σ=0.1 1.19
22	σ=0.2 2.43	σ=0.2 1.98	σ=0.2 1.68	σ=0.1 1.31	σ=0.1 1.22	σ=0.1 1.20	σ=0.1 1.19	σ=0.1 1.18	σ=0.1 1.17
21	σ=0.2 2.43	σ=0.2 1.97	σ=0.2 1.68	σ=0.1 1.31	σ=0.1 1.21	σ=0.1 1.19	σ=0.1 1.18	σ=0.1 1.17	σ=0.1 1.17

Izmir (TUR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.60	σ=0.2 2.27	σ=0.2 2.07	σ=0.1 1.93	σ=0.1 1.88	σ=0.1 1.83	σ=0.1 1.79	σ=0.1 1.74	σ=0.1 1.70
24	σ=0.2 2.58	σ=0.2 2.08	σ=0.2 1.62	σ=0.1 0.97	σ=0.1 0.67	σ=0.1 0.58	σ=0.1 0.55	σ=0.1 0.53	σ=0.1 0.53
23	σ=0.2 2.58	σ=0.2 2.07	σ=0.2 1.60	σ=0.1 0.93	σ=0.1 0.63	σ=0.1 0.55	σ=0.1 0.52	σ=0.1 0.51	σ=0.1 0.50
22	σ=0.2 2.58	σ=0.2 2.06	σ=0.2 1.59	σ=0.1 0.91	σ=0.1 0.61	σ=0.1 0.52	σ=0.1 0.49	σ=0.1 0.49	σ=0.1 0.48
21	σ=0.2 2.58	σ=0.2 2.06	σ=0.2 1.59	σ=0.1 0.91	σ=0.1 0.59	σ=0.1 0.51	σ=0.1 0.48	σ=0.1 0.47	σ=0.1 0.47

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.60	σ=0.2 2.27	σ=0.2 2.08	σ=0.1 1.97	σ=0.1 1.97	σ=0.1 1.93	σ=0.1 1.87	σ=0.1 1.80	σ=0.1 1.75
24	σ=0.2 2.58	σ=0.2 2.08	σ=0.2 1.63	σ=0.1 1.03	σ=0.1 0.79	σ=0.1 0.75	σ=0.1 0.74	σ=0.1 0.73	σ=0.1 0.72
23	σ=0.2 2.58	σ=0.2 2.07	σ=0.2 1.62	σ=0.1 0.99	σ=0.1 0.75	σ=0.1 0.72	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.69
22	σ=0.2 2.58	σ=0.2 2.06	σ=0.2 1.61	σ=0.1 0.97	σ=0.1 0.73	σ=0.1 0.69	σ=0.1 0.69	σ=0.1 0.68	σ=0.1 0.67
21	σ=0.2 2.57	σ=0.2 2.06	σ=0.2 1.60	σ=0.1 0.96	σ=0.1 0.71	σ=0.1 0.68	σ=0.1 0.67	σ=0.1 0.66	σ=0.1 0.66

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.59	σ=0.2 2.28	σ=0.2 2.11	σ=0.1 2.07	σ=0.1 2.09	σ=0.1 2.01	σ=0.1 1.93	σ=0.1 1.87	σ=0.1 1.83
24	σ=0.2 2.58	σ=0.2 2.09	σ=0.2 1.68	σ=0.1 1.15	σ=0.1 1.02	σ=0.1 1.00	σ=0.1 0.99	σ=0.1 0.97	σ=0.1 0.96
23	σ=0.2 2.58	σ=0.2 2.08	σ=0.2 1.66	σ=0.1 1.12	σ=0.1 0.98	σ=0.1 0.96	σ=0.1 0.95	σ=0.1 0.94	σ=0.1 0.93
22	σ=0.2 2.57	σ=0.2 2.08	σ=0.2 1.65	σ=0.1 1.10	σ=0.1 0.96	σ=0.1 0.94	σ=0.1 0.92	σ=0.1 0.91	σ=0.1 0.90
21	σ=0.2 2.57	σ=0.2 2.07	σ=0.2 1.65	σ=0.1 1.09	σ=0.1 0.94	σ=0.1 0.92	σ=0.1 0.91	σ=0.1 0.90	σ=0.1 0.89

Athens (GRC)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.95	σ=0.2 2.72	σ=0.2 2.59	σ=0.2 2.43	σ=0.1 2.33	σ=0.1 2.30	σ=0.1 2.28	σ=0.1 2.28	σ=0.1 2.26
24	σ=0.2 2.94	σ=0.2 2.54	σ=0.2 2.27	σ=0.1 1.85	σ=0.1 1.53	σ=0.1 1.39	σ=0.1 1.32	σ=0.1 1.31	σ=0.1 1.31
23	σ=0.2 2.93	σ=0.2 2.53	σ=0.2 2.25	σ=0.1 1.83	σ=0.1 1.51	σ=0.1 1.37	σ=0.1 1.31	σ=0.1 1.29	σ=0.1 1.29
22	σ=0.2 2.93	σ=0.2 2.53	σ=0.2 2.25	σ=0.1 1.82	σ=0.1 1.51	σ=0.1 1.36	σ=0.1 1.30	σ=0.1 1.28	σ=0.1 1.28
21	σ=0.2 2.93	σ=0.2 2.52	σ=0.2 2.24	σ=0.1 1.82	σ=0.1 1.50	σ=0.1 1.36	σ=0.1 1.29	σ=0.1 1.28	σ=0.1 1.28

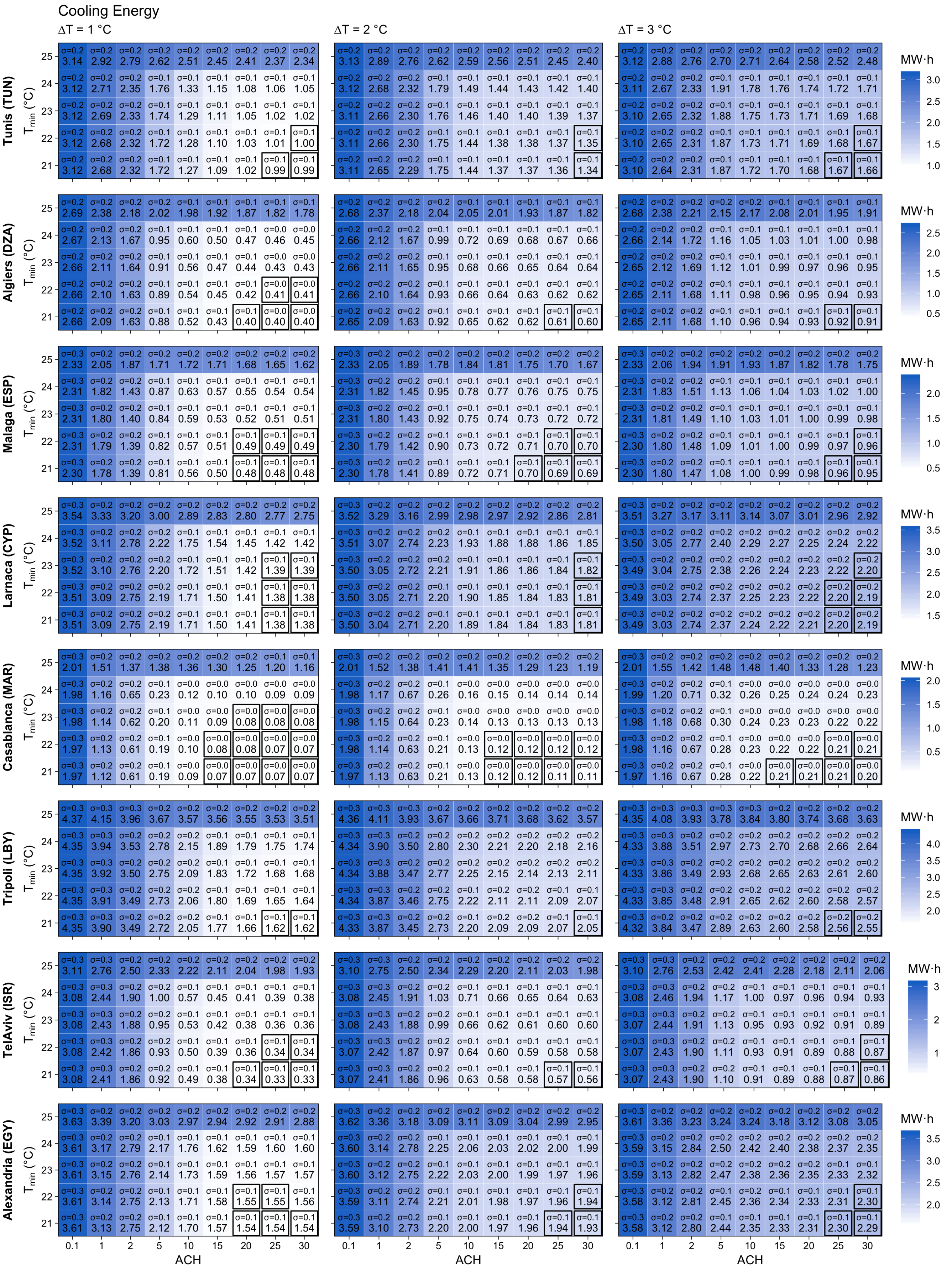
ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.95	σ=0.2 2.70	σ=0.2 2.58	σ=0.2 2.48	σ=0.2 2.46	σ=0.1 2.46	σ=0.1 2.42	σ=0.1 2.38	σ=0.1 2.35
24	σ=0.2 2.93	σ=0.2 2.53	σ=0.1 2.27	σ=0.1 1.92	σ=0.1 1.74	σ=0.1 1.72	σ=0.1 1.71	σ=0.1 1.70	σ=0.1 1.68
23	σ=0.2 2.93	σ=0.2 2.51	σ=0.2 2.25	σ=0.1 1.91	σ=0.1 1.73	σ=0.1 1.70	σ=0.1 1.69	σ=0.1 1.68	σ=0.1 1.67
22	σ=0.2 2.93	σ=0.2 2.51	σ=0.2 2.25	σ=0.1 1.90	σ=0.1 1.72	σ=0.1 1.69	σ=0.1 1.68	σ=0.1 1.67	σ=0.1 1.66
21	σ=0.2 2.92	σ=0.2 2.50	σ=0.1 2.24	σ=0.1 1.90	σ=0.1 1.71	σ=0.1 1.68	σ=0.1 1.68	σ=0.1 1.66	σ=0.1 1.65

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.94	σ=0.2 2.70	σ=0.2 2.61	σ=0.2 2.58	σ=0.2 2.59	σ=0.2 2.55	σ=0.2 2.51	σ=0.1 2.47	σ=0.1 2.44
24	σ=0.2 2.93	σ=0.2 2.53	σ=0.1 2.31	σ=0.1 2.06	σ=0.1 2.00	σ=0.1 1.98	σ=0.1 1.97	σ=0.1 1.96	σ=0.1 1.95
23	σ=0.2 2.93	σ=0.2 2.52	σ=0.1 2.29	σ=0.1 2.05	σ=0.1 1.98	σ=0.1 1.96	σ=0.1 1.95	σ=0.1 1.94	σ=0.1 1.93
22	σ=0.2 2.92	σ=0.2 2.51	σ=0.1 2.28	σ=0.1 2.04	σ=0.1 1.97	σ=0.1 1.95	σ=0.1 1.94	σ=0.1 1.93	σ=0.1 1.92
21	σ=0.2 2.92	σ=0.2 2.51	σ=0.1 2.28	σ=0.1 2.03	σ=0.1 1.96	σ=0.1 1.95	σ=0.1 1.93	σ=0.1 1.92	σ=0.1 1.91

Fig. A.3. Cooling air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT), for different climate locations (part 1/2). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.



Tunis (TUN)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 3.14	σ=0.2 2.92	σ=0.2 2.79	σ=0.2 2.62	σ=0.2 2.51	σ=0.2 2.45	σ=0.2 2.41	σ=0.2 2.37	σ=0.2 2.34
24	σ=0.2 3.12	σ=0.2 2.71	σ=0.2 2.35	σ=0.1 1.76	σ=0.1 1.33	σ=0.1 1.15	σ=0.1 1.08	σ=0.1 1.06	σ=0.1 1.05
23	σ=0.2 3.12	σ=0.2 2.69	σ=0.2 2.33	σ=0.1 1.74	σ=0.1 1.29	σ=0.1 1.11	σ=0.1 1.05	σ=0.1 1.02	σ=0.1 1.02
22	σ=0.2 3.12	σ=0.2 2.68	σ=0.2 2.32	σ=0.1 1.72	σ=0.1 1.28	σ=0.1 1.10	σ=0.1 1.03	σ=0.1 1.01	σ=0.1 1.00
21	σ=0.2 3.12	σ=0.2 2.68	σ=0.2 2.32	σ=0.1 1.72	σ=0.1 1.27	σ=0.1 1.09	σ=0.1 1.02	σ=0.1 0.99	σ=0.1 0.99

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 3.13	σ=0.2 2.89	σ=0.2 2.76	σ=0.2 2.62	σ=0.2 2.59	σ=0.2 2.56	σ=0.2 2.51	σ=0.2 2.45	σ=0.2 2.40
24	σ=0.2 3.12	σ=0.2 2.68	σ=0.2 2.32	σ=0.1 1.79	σ=0.1 1.49	σ=0.1 1.44	σ=0.1 1.43	σ=0.1 1.42	σ=0.1 1.40
23	σ=0.2 3.11	σ=0.2 2.66	σ=0.2 2.30	σ=0.1 1.76	σ=0.1 1.46	σ=0.1 1.40	σ=0.1 1.40	σ=0.1 1.39	σ=0.1 1.37
22	σ=0.2 3.11	σ=0.2 2.66	σ=0.2 2.30	σ=0.1 1.75	σ=0.1 1.44	σ=0.1 1.38	σ=0.1 1.38	σ=0.1 1.37	σ=0.1 1.35
21	σ=0.2 3.11	σ=0.2 2.65	σ=0.2 2.29	σ=0.1 1.75	σ=0.1 1.44	σ=0.1 1.37	σ=0.1 1.37	σ=0.1 1.36	σ=0.1 1.34

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 3.12	σ=0.2 2.88	σ=0.2 2.76	σ=0.2 2.70	σ=0.2 2.71	σ=0.2 2.64	σ=0.2 2.58	σ=0.2 2.52	σ=0.2 2.48
24	σ=0.2 3.11	σ=0.2 2.67	σ=0.2 2.33	σ=0.1 1.91	σ=0.1 1.78	σ=0.1 1.76	σ=0.1 1.74	σ=0.1 1.72	σ=0.1 1.71
23	σ=0.2 3.10	σ=0.2 2.65	σ=0.2 2.32	σ=0.1 1.88	σ=0.1 1.75	σ=0.1 1.73	σ=0.1 1.71	σ=0.1 1.69	σ=0.1 1.68
22	σ=0.2 3.10	σ=0.2 2.65	σ=0.2 2.31	σ=0.1 1.87	σ=0.1 1.73	σ=0.1 1.71	σ=0.1 1.69	σ=0.1 1.68	σ=0.1 1.67
21	σ=0.2 3.10	σ=0.2 2.64	σ=0.2 2.31	σ=0.1 1.87	σ=0.1 1.72	σ=0.1 1.70	σ=0.1 1.68	σ=0.1 1.67	σ=0.1 1.66

Algiers (DZA)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.69	σ=0.2 2.38	σ=0.2 2.18	σ=0.2 2.02	σ=0.1 1.98	σ=0.1 1.92	σ=0.1 1.87	σ=0.1 1.82	σ=0.1 1.78
24	σ=0.2 2.67	σ=0.2 2.13	σ=0.2 1.67	σ=0.1 0.95	σ=0.1 0.60	σ=0.1 0.50	σ=0.1 0.47	σ=0.0 0.46	σ=0.0 0.45
23	σ=0.2 2.66	σ=0.2 2.11	σ=0.2 1.64	σ=0.1 0.91	σ=0.1 0.56	σ=0.1 0.47	σ=0.1 0.44	σ=0.0 0.43	σ=0.0 0.43
22	σ=0.2 2.66	σ=0.2 2.10	σ=0.2 1.63	σ=0.1 0.89	σ=0.1 0.54	σ=0.1 0.45	σ=0.1 0.42	σ=0.0 0.41	σ=0.0 0.41
21	σ=0.2 2.66	σ=0.2 2.09	σ=0.2 1.63	σ=0.1 0.88	σ=0.1 0.52	σ=0.1 0.43	σ=0.1 0.40	σ=0.0 0.40	σ=0.0 0.40

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.68	σ=0.2 2.37	σ=0.2 2.18	σ=0.2 2.04	σ=0.1 2.05	σ=0.1 2.01	σ=0.1 1.93	σ=0.1 1.87	σ=0.1 1.82
24	σ=0.2 2.66	σ=0.2 2.12	σ=0.2 1.67	σ=0.1 0.99	σ=0.1 0.72	σ=0.1 0.69	σ=0.1 0.68	σ=0.1 0.67	σ=0.1 0.66
23	σ=0.2 2.66	σ=0.2 2.11	σ=0.2 1.65	σ=0.1 0.95	σ=0.1 0.68	σ=0.1 0.66	σ=0.1 0.65	σ=0.1 0.64	σ=0.1 0.64
22	σ=0.2 2.66	σ=0.2 2.10	σ=0.2 1.64	σ=0.1 0.93	σ=0.1 0.66	σ=0.1 0.64	σ=0.1 0.63	σ=0.1 0.62	σ=0.1 0.62
21	σ=0.2 2.65	σ=0.2 2.09	σ=0.2 1.63	σ=0.1 0.92	σ=0.1 0.65	σ=0.1 0.62	σ=0.1 0.62	σ=0.1 0.61	σ=0.1 0.60

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.2 2.68	σ=0.2 2.38	σ=0.2 2.21	σ=0.2 2.15	σ=0.2 2.17	σ=0.1 2.08	σ=0.1 2.01	σ=0.1 1.95	σ=0.1 1.91
24	σ=0.2 2.66	σ=0.2 2.14	σ=0.2 1.72	σ=0.1 1.16	σ=0.1 1.05	σ=0.1 1.03	σ=0.1 1.01	σ=0.1 1.00	σ=0.1 0.98
23	σ=0.2 2.65	σ=0.2 2.12	σ=0.2 1.69	σ=0.1 1.12	σ=0.1 1.01	σ=0.1 0.99	σ=0.1 0.97	σ=0.1 0.96	σ=0.1 0.95
22	σ=0.2 2.65	σ=0.2 2.11	σ=0.2 1.68	σ=0.1 1.11	σ=0.1 0.98	σ=0.1 0.96	σ=0.1 0.95	σ=0.1 0.94	σ=0.1 0.93
21	σ=0.2 2.65	σ=0.2 2.11	σ=0.2 1.68	σ=0.1 1.10	σ=0.1 0.96	σ=0.1 0.94	σ=0.1 0.93	σ=0.1 0.92	σ=0.1 0.91

Malaga (ESP)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.33	σ=0.2 2.05	σ=0.2 1.87	σ=0.2 1.71	σ=0.2 1.72	σ=0.2 1.71	σ=0.2 1.68	σ=0.2 1.65	σ=0.2 1.62
24	σ=0.3 2.31	σ=0.2 1.82	σ=0.2 1.43	σ=0.1 0.87	σ=0.1 0.63	σ=0.1 0.57	σ=0.1 0.55	σ=0.1 0.54	σ=0.1 0.54
23	σ=0.3 2.31	σ=0.2 1.80	σ=0.2 1.40	σ=0.1 0.84	σ=0.1 0.59	σ=0.1 0.53	σ=0.1 0.52	σ=0.1 0.51	σ=0.1 0.51
22	σ=0.3 2.31	σ=0.2 1.79	σ=0.2 1.39	σ=0.1 0.82	σ=0.1 0.57	σ=0.1 0.51	σ=0.1 0.49	σ=0.1 0.49	σ=0.1 0.49
21	σ=0.3 2.30	σ=0.2 1.78	σ=0.2 1.39	σ=0.1 0.81	σ=0.1 0.56	σ=0.1 0.50	σ=0.1 0.48	σ=0.1 0.48	σ=0.1 0.48

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.33	σ=0.2 2.05	σ=0.2 1.89	σ=0.2 1.78	σ=0.2 1.84	σ=0.2 1.81	σ=0.2 1.75	σ=0.2 1.70	σ=0.2 1.67
24	σ=0.3 2.31	σ=0.2 1.82	σ=0.2 1.45	σ=0.1 0.95	σ=0.1 0.78	σ=0.1 0.77	σ=0.1 0.76	σ=0.1 0.75	σ=0.1 0.75
23	σ=0.3 2.31	σ=0.2 1.80	σ=0.2 1.43	σ=0.1 0.92	σ=0.1 0.75	σ=0.1 0.74	σ=0.1 0.73	σ=0.1 0.72	σ=0.1 0.72
22	σ=0.3 2.30	σ=0.2 1.79	σ=0.2 1.42	σ=0.1 0.90	σ=0.1 0.73	σ=0.1 0.72	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.70
21	σ=0.3 2.30	σ=0.2 1.78	σ=0.2 1.41	σ=0.1 0.89	σ=0.1 0.72	σ=0.1 0.71	σ=0.1 0.70	σ=0.1 0.69	σ=0.1 0.69

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.33	σ=0.2 2.06	σ=0.2 1.94	σ=0.2 1.91	σ=0.2 1.93	σ=0.2 1.87	σ=0.2 1.82	σ=0.2 1.78	σ=0.2 1.75
24	σ=0.3 2.31	σ=0.2 1.83	σ=0.2 1.51	σ=0.1 1.13	σ=0.1 1.06	σ=0.1 1.04	σ=0.1 1.03	σ=0.1 1.02	σ=0.1 1.00
23	σ=0.3 2.31	σ=0.2 1.81	σ=0.2 1.49	σ=0.1 1.10	σ=0.1 1.03	σ=0.1 1.01	σ=0.1 1.00	σ=0.1 0.99	σ=0.1 0.98
22	σ=0.3 2.30	σ=0.2 1.80	σ=0.2 1.48	σ=0.1 1.09	σ=0.1 1.01	σ=0.1 1.00	σ=0.1 0.99	σ=0.1 0.97	σ=0.1 0.96
21	σ=0.3 2.30	σ=0.2 1.80	σ=0.2 1.47	σ=0.1 1.08	σ=0.1 1.00	σ=0.1 0.99	σ=0.1 0.98	σ=0.1 0.96	σ=0.1 0.95

Larnaca (CYP)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.54	σ=0.2 3.33	σ=0.2 3.20	σ=0.2 3.00	σ=0.2 2.89	σ=0.2 2.83	σ=0.2 2.80	σ=0.2 2.77	σ=0.2 2.75
24	σ=0.3 3.52	σ=0.2 3.11	σ=0.2 2.78	σ=0.2 2.22	σ=0.1 1.75	σ=0.1 1.54	σ=0.1 1.45	σ=0.1 1.42	σ=0.1 1.42
23	σ=0.3 3.52	σ=0.2 3.10	σ=0.2 2.76	σ=0.2 2.20	σ=0.1 1.72	σ=0.1 1.51	σ=0.1 1.42	σ=0.1 1.39	σ=0.1 1.39
22	σ=0.3 3.51	σ=0.2 3.09	σ=0.2 2.75	σ=0.2 2.19	σ=0.1 1.71	σ=0.1 1.50	σ=0.1 1.41	σ=0.1 1.38	σ=0.1 1.38
21	σ=0.3 3.51	σ=0.2 3.09	σ=0.2 2.75	σ=0.2 2.19	σ=0.1 1.71	σ=0.1 1.50	σ=0.1 1.41	σ=0.1 1.38	σ=0.1 1.38

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.52	σ=0.2 3.29	σ=0.2 3.16	σ=0.2 2.99	σ=0.2 2.98	σ=0.2 2.97	σ=0.2 2.92	σ=0.2 2.86	σ=0.2 2.81
24	σ=0.3 3.51	σ=0.2 3.07	σ=0.2 2.74	σ=0.2 2.23	σ=0.1 1.93	σ=0.1 1.88	σ=0.1 1.88	σ=0.1 1.86	σ=0.1 1.85
23	σ=0.3 3.50	σ=0.2 3.05	σ=0.2 2.72	σ=0.2 2.21	σ=0.1 1.91	σ=0.1 1.86	σ=0.1 1.86	σ=0.1 1.84	σ=0.1 1.82
22	σ=0.3 3.50	σ=0.2 3.05	σ=0.2 2.71	σ=0.1 2.20	σ=0.1 1.90	σ=0.1 1.85	σ=0.1 1.84	σ=0.1 1.83	σ=0.1 1.81
21	σ=0.3 3.50	σ=0.2 3.04	σ=0.2 2.71	σ=0.1 2.20	σ=0.1 1.89	σ=0.1 1.84	σ=0.1 1.84	σ=0.1 1.83	σ=0.1 1.81

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.51	σ=0.2 3.27	σ=0.2 3.17	σ=0.2 3.11	σ=0.2 3.14	σ=0.2 3.07	σ=0.2 3.01	σ=0.2 2.96	σ=0.2 2.92
24	σ=0.3 3.50	σ=0.2 3.05	σ=0.2 2.77	σ=0.2 2.40	σ=0.2 2.29	σ=0.2 2.27	σ=0.2 2.25	σ=0.2 2.24	σ=0.2 2.22
23	σ=0.3 3.49	σ=0.2 3.04	σ=0.2 2.75	σ=0.2 2.38	σ=0.2 2.26	σ=0.2 2.24	σ=0.2 2.23	σ=0.2 2.22	σ=0.2 2.20
22	σ=0.3 3.49	σ=0.2 3.03	σ=0.2 2.74	σ=0.2 2.37	σ=0.2 2.25	σ=0.2 2.23	σ=0.2 2.22	σ=0.2 2.20	σ=0.2 2.19
21	σ=0.3 3.49	σ=0.2 3.03	σ=0.2 2.74	σ=0.2 2.37	σ=0.2 2.24	σ=0.2 2.22	σ=0.2 2.21	σ=0.2 2.20	σ=0.2 2.19

Casablanca (MAR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.01	σ=0.2 1.51	σ=0.2 1.37	σ=0.2 1.38	σ=0.2 1.36	σ=0.2 1.30	σ=0.2 1.25	σ=0.1 1.20	σ=0.1 1.16
24	σ=0.3 1.98	σ=0.2 1.16	σ=0.2 0.65	σ=0.1 0.23	σ=0.0 0.12	σ=0.0 0.10	σ=0.0 0.10	σ=0.0 0.09	σ=0.0 0.09
23	σ=0.3 1.98	σ=0.2 1.14	σ=0.2 0.62	σ=0.1 0.20	σ=0.0 0.11	σ=0.0 0.09	σ=0.0 0.08	σ=0.0 0.08	σ=0.0 0.08
22	σ=0.3 1.97	σ=0.2 1.13	σ=0.2 0.61	σ=0.1 0.19	σ=0.0 0.10	σ=0.0 0.08	σ=0.0 0.08	σ=0.0 0.07	σ=0.0 0.07
21	σ=0.3 1.97	σ=0.2 1.12	σ=0.2 0.61	σ=0.1 0.19	σ=0.0 0.09	σ=0.0 0.07	σ=0.0 0.07	σ=0.0 0.07	σ=0.0 0.07

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.01	σ=0.2 1.52	σ=0.2 1.38	σ=0.2 1.41	σ=0.2 1.41	σ=0.2 1.35	σ=0.2 1.29	σ=0.2 1.23	σ=0.2 1.19
24	σ=0.3 1.98	σ=0.2 1.17	σ=0.2 0.67	σ=0.1 0.26	σ=0.0 0.16	σ=0.0 0.15	σ=0.0 0.14	σ=0.0 0.14	σ=0.0 0.14
23	σ=0.3 1.98	σ=0.2 1.15	σ=0.2 0.64	σ=0.1 0.23	σ=0.0 0.14	σ=0.0 0.13	σ=0.0 0.13	σ=0.0 0.13	σ=0.0 0.13
22	σ=0.3 1.98	σ=0.2 1.14	σ=0.2 0.63	σ=0.1 0.21	σ=0.0 0.13	σ=0.0 0.12	σ=0.0 0.12	σ=0.0 0.12	σ=0.0 0.12
21	σ=0.3 1.97	σ=0.2 1.13	σ=0.2 0.63	σ=0.1 0.21	σ=0.0 0.13	σ=0.0 0.12	σ=0.0 0.12	σ=0.0 0.11	σ=0.0 0.11

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 2.01	σ=0.2 1.55	σ=0.2 1.42	σ=0.2 1.48	σ=0.2 1.48	σ=0.2 1.40	σ=0.2 1.33	σ=0.2 1.28	σ=0.2 1.23
24	σ=0.3 1.99	σ=0.2 1.20	σ=0.2 0.71	σ=0.1 0.32	σ=0.0 0.26	σ=0.0 0.25	σ=0.0 0.24	σ=0.0 0.24	σ=0.0 0.23
23	σ=0.3 1.98	σ=0.2 1.18	σ=0.2 0.68	σ=0.1 0.30	σ=0.0 0.24	σ=0.0 0.23	σ=0.0 0.23	σ=0.0 0.22	σ=0.0 0.22
22	σ=0.3 1.98	σ=0.2 1.16	σ=0.2 0.67	σ=0.1 0.28	σ=0.0 0.23	σ=0.0 0.22	σ=0.0 0.22	σ=0.0 0.21	σ=0.0 0.21
21	σ=0.3 1.97	σ=0.2 1.16	σ=0.2 0.67	σ=0.1 0.28	σ=0.0 0.22	σ=0.0 0.21	σ=0.0 0.21	σ=0.0 0.21	σ=0.0 0.20

Tripoli (LBY)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 4.37	σ=0.3 4.15	σ=0.3 3.96	σ=0.2 3.67	σ=0.2 3.57	σ=0.2 3.56	σ=0.2 3.55	σ=0.2 3.53	σ=0.2 3.51
24	σ=0.3 4.35	σ=0.3 3.94	σ=0.2 3.53	σ=0.2 2.78	σ=0.2 2.15	σ=0.1 1.89	σ=0.1 1.79	σ=0.1 1.75	σ=0.1 1.74
23	σ=0.3 4.35	σ=0.3 3.92	σ=0.2 3.50	σ=0.2 2.75	σ=0.2 2.09	σ=0.1 1.83	σ=0.1 1.72	σ=0.1 1.68	σ=0.1 1.68
22	σ=0.3 4.35	σ=0.3 3.91	σ=0.2 3.49	σ=0.2 2.73	σ=0.2 2.06	σ=0.1 1.80	σ=0.1 1.69	σ=0.1 1.65	σ=0.1 1.64
21	σ=0.3 4.35	σ=0.3 3.90	σ=0.2 3.49	σ=0.2 2.72	σ=0.2 2.05	σ=0.1 1.77	σ=0.1 1.66	σ=0.1 1.62	σ=0.1 1.62

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 4.36	σ=0.3 4.11	σ=0.3 3.93	σ=0.2 3.67	σ=0.2 3.66	σ=0.2 3.71	σ=0.2 3.68	σ=0.2 3.62	σ=0.2 3.57
24	σ=0.3 4.34	σ=0.3 3.90	σ=0.2 3.50	σ=0.2 2.80	σ=0.2 2.30	σ=0.2 2.21	σ=0.2 2.20	σ=0.2 2.18	σ=0.2 2.16
23	σ=0.3 4.34	σ=0.3 3.88	σ=0.2 3.47	σ=0.2 2.77	σ=0.2 2.25	σ=0.2 2.15	σ=0.2 2.14	σ=0.2 2.13	σ=0.2 2.11
22	σ=0.3 4.34	σ=0.3 3.87	σ=0.2 3.46	σ=0.2 2.75	σ=0.1 2.22	σ=0.2 2.11	σ=0.2 2.11	σ=0.1 2.09	σ=0.1 2.07
21	σ=0.3 4.33	σ=0.3 3.87	σ=0.2 3.45	σ=0.2 2.73	σ=0.1 2.20	σ=0.2 2.09	σ=0.2 2.09	σ=0.1 2.07	σ=0.1 2.05

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 4.35	σ=0.3 4.08	σ=0.3 3.93	σ=0.3 3.78	σ=0.3 3.84	σ=0.2 3.80	σ=0.2 3.74	σ=0.2 3.68	σ=0.2 3.63
24	σ=0.3 4.33	σ=0.3 3.88	σ=0.2 3.51	σ=0.2 2.97	σ=0.2 2.73	σ=0.2 2.70	σ=0.2 2.68	σ=0.2 2.66	σ=0.2 2.64
23	σ=0.3 4.33	σ=0.3 3.86	σ=0.2 3.49	σ=0.2 2.93	σ=0.2 2.68	σ=0.2 2.65	σ=0.2 2.63	σ=0.2 2.61	σ=0.2 2.60
22	σ=0.3 4.33	σ=0.3 3.85	σ=0.2 3.48	σ=0.2 2.91	σ=0.2 2.65	σ=0.2 2.62	σ=0.2 2.60	σ=0.2 2.58	σ=0.2 2.57
21	σ=0.3 4.32	σ=0.2 3.84	σ=0.2 3.47	σ=0.2 2.89	σ=0.2 2.63	σ=0.2 2.60	σ=0.2 2.58	σ=0.2 2.56	σ=0.2 2.55

TelAviv (ISR)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.11	σ=0.3 2.76	σ=0.2 2.50	σ=0.2 2.33	σ=0.2 2.22	σ=0.2 2.11	σ=0.2 2.04	σ=0.2 1.98	σ=0.2 1.93
24	σ=0.3 3.08	σ=0.3 2.44	σ=0.2 1.90	σ=0.2 1.00	σ=0.1 0.57	σ=0.1 0.45	σ=0.1 0.41	σ=0.1 0.39	σ=0.1 0.38
23	σ=0.3 3.08	σ=0.3 2.43	σ=0.2 1.88	σ=0.2 0.95	σ=0.1 0.53	σ=0.1 0.42	σ=0.1 0.38	σ=0.1 0.36	σ=0.1 0.36
22	σ=0.3 3.08	σ=0.3 2.42	σ=0.2 1.86	σ=0.2 0.93	σ=0.1 0.50	σ=0.1 0.39	σ=0.1 0.36	σ=0.1 0.34	σ=0.1 0.34
21	σ=0.3 3.08	σ=0.3 2.41	σ=0.2 1.86	σ=0.2 0.92	σ=0.1 0.49	σ=0.1 0.38	σ=0.1 0.34	σ=0.1 0.33	σ=0.1 0.33

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.10	σ=0.3 2.75	σ=0.2 2.50	σ=0.2 2.34	σ=0.2 2.29	σ=0.2 2.20	σ=0.2 2.11	σ=0.2 2.03	σ=0.2 1.98
24	σ=0.3 3.08	σ=0.3 2.45	σ=0.2 1.91	σ=0.2 1.03	σ=0.1 0.71	σ=0.1 0.66	σ=0.1 0.65	σ=0.1 0.64	σ=0.1 0.63
23	σ=0.3 3.08	σ=0.3 2.43	σ=0.2 1.88	σ=0.2 0.99	σ=0.1 0.66	σ=0.1 0.62	σ=0.1 0.61	σ=0.1 0.60	σ=0.1 0.60
22	σ=0.3 3.07	σ=0.3 2.42	σ=0.2 1.87	σ=0.2 0.97	σ=0.1 0.64	σ=0.1 0.60	σ=0.1 0.59	σ=0.1 0.58	σ=0.1 0.58
21	σ=0.3 3.07	σ=0.3 2.41	σ=0.2 1.86	σ=0.2 0.96	σ=0.1 0.63	σ=0.1 0.58	σ=0.1 0.58	σ=0.1 0.57	σ=0.1 0.56

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.10	σ=0.3 2.76	σ=0.2 2.53	σ=0.2 2.42	σ=0.2 2.41	σ=0.2 2.28	σ=0.2 2.18	σ=0.2 2.11	σ=0.2 2.06
24	σ=0.3 3.08	σ=0.3 2.46	σ=0.2 1.94	σ=0.2 1.17	σ=0.1 1.00	σ=0.1 0.97	σ=0.1 0.96	σ=0.1 0.94	σ=0.1 0.93
23	σ=0.3 3.07	σ=0.3 2.44	σ=0.2 1.91	σ=0.2 1.13	σ=0.1 0.95	σ=0.1 0.93	σ=0.1 0.92	σ=0.1 0.91	σ=0.1 0.89
22	σ=0.3 3.07	σ=0.3 2.43	σ=0.2 1.90	σ=0.2 1.11	σ=0.1 0.93	σ=0.1 0.91	σ=0.1 0.89	σ=0.1 0.88	σ=0.1 0.87
21	σ=0.3 3.07	σ=0.3 2.43	σ=0.2 1.90	σ=0.2 1.10	σ=0.1 0.91	σ=0.1 0.89	σ=0.1 0.88	σ=0.1 0.87	σ=0.1 0.86

Alexandria (EGY)

ΔT = 1 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.63	σ=0.2 3.39	σ=0.2 3.20	σ=0.2 3.03	σ=0.2 2.97	σ=0.2 2.94	σ=0.2 2.92	σ=0.2 2.91	σ=0.2 2.88
24	σ=0.3 3.61	σ=0.2 3.17	σ=0.2 2.79	σ=0.1 2.17	σ=0.1 1.76	σ=0.1 1.62	σ=0.1 1.59	σ=0.1 1.60	σ=0.1 1.60
23	σ=0.3 3.61	σ=0.2 3.15	σ=0.2 2.76	σ=0.1 2.14	σ=0.1 1.73	σ=0.1 1.59	σ=0.1 1.56	σ=0.1 1.57	σ=0.1 1.57
22	σ=0.3 3.61	σ=0.2 3.14	σ=0.2 2.75	σ=0.1 2.13	σ=0.1 1.71	σ=0.1 1.58	σ=0.1 1.55	σ=0.1 1.55	σ=0.1 1.56
21	σ=0.3 3.61	σ=0.2 3.13	σ=0.2 2.75	σ=0.1 2.12	σ=0.1 1.70	σ=0.1 1.57	σ=0.1 1.54	σ=0.1 1.54	σ=0.1 1.54

ΔT = 2 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.62	σ=0.2 3.36	σ=0.2 3.18	σ=0.2 3.09	σ=0.2 3.11	σ=0.2 3.09	σ=0.2 3.04	σ=0.2 2.99	σ=0.2 2.95
24	σ=0.3 3.60	σ=0.2 3.14	σ=0.2 2.78	σ=0.1 2.25	σ=0.1 2.06	σ=0.1 2.03	σ=0.1 2.02	σ=0.1 2.00	σ=0.1 1.99
23	σ=0.3 3.60	σ=0.2 3.12	σ=0.2 2.75	σ=0.1 2.22	σ=0.1 2.03	σ=0.1 2.00	σ=0.1 1.99	σ=0.1 1.97	σ=0.1 1.96
22	σ=0.3 3.59	σ=0.2 3.11	σ=0.2 2.74	σ=0.1 2.21	σ=0.1 2.01	σ=0.1 1.98	σ=0.1 1.97	σ=0.1 1.96	σ=0.1 1.94
21	σ=0.3 3.59	σ=0.2 3.10	σ=0.2 2.73	σ=0.1 2.20	σ=0.1 2.00	σ=0.1 1.97	σ=0.1 1.96	σ=0.1 1.94	σ=0.1 1.93

ΔT = 3 °C

T_{min} (°C)	0.1	1	2	5	10	15	20	25	30
25	σ=0.3 3.61	σ=0.2 3.36	σ=0.2 3.23	σ=0.2 3.24	σ=0.2 3.24	σ=0.2 3.18	σ=0.2 3.12	σ=0.2 3.08	σ=0.2 3.05
24	σ=0.3 3.59	σ=0.2 3.15	σ=0.2 2.84	σ=0.2 2.50	σ=0.2 2.42	σ=0.2 2.40	σ=0.2 2.38	σ=0.2 2.37	σ=0.2 2.35
23	σ=0.3 3.59	σ=0.2 3.13	σ=0.2 2.82	σ=0.2 2.47	σ=0.2 2.38	σ=0.2 2.36	σ=0.2 2.35	σ=0.1 2.33	σ=0.1 2.32
22	σ=0.3 3.58	σ=0.2 3.12	σ=0.2 2.81	σ=0.1 2.45	σ=0.2 2.36	σ=0.1 2.34	σ=0.1 2.33	σ=0.1 2.31	σ=0.1 2.30
21	σ=0.3 3.58	σ=0.2 3.12	σ=0.2 2.80	σ=0.1 2.44	σ=0.1 2.35	σ=0.1 2.33	σ=0.1 2.31	σ=0.1 2.30	σ=0.1 2.29

ACH

Fig. A.4. Cooling air-conditioning energy consumption per ventilation parameter (ACH, T_{min} and ΔT), for different climate locations (part 2/2). The energy consumption values falling within the interval of 0.01 MW · h of the lowest value are marked with a black rectangle.