Simulation model for the evaluation of the effect of office dressing code on building space cooling demand

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Abstract:

The indoor air temperature in buildings is one of the main parameters determining both the indoor thermal comfort of inhabitants and the energy consumption of the Heating, Ventilation and Air Conditioning systems (HVAC). Clothing insulation of building residents is a key factor dramatically affecting people thermal comfort and HVAC energy demand. Indoor set point temperature, depends on clothing factor, relative humidity and mean radiant temperature. Although the clothing insulation values are selected according to well-known standards, clothing insulation depends on several factors: the metabolic heat production, activity and gender (females tend to be cooler than males in cool conditions). Therefore, users can adjust their clothing insulation according to the outdoor temperature change, suiting their own thermal comfort requirement. In this framework, a dynamic simulation model for the evaluation of the comfort conditions and the cooling energy consumption based on the variation in clothing insulation for office applications is developed in the present work. In order to calculate the space cooling demand, a suitable thermal zone was modelled by the TRNSYS Type 56 coupled to the Google SketchUp TRNSYS3d plug-in. The model was validated and applied to a suitable case study, an office room located at University of Federico II in Naples (Italy). Different sensitivity analyses were performed changing the clothing insulation and the office set-point temperature, to estimate both the comfort conditions and cooling energy demands. The model can be considered a flexible tool to suggest simple clothing adjustment behaviors which may represent a tradeoff among thermal comfort, energy saving and dressing code.

Keywords:

Dynamic simulations, Clothing insulation, Building energy saving, Thermal comfort

1. Introduction

In 2020, the global building sector accounted for 36% of energy consumption and 37% of CO_2 emissions, while the residential sector accounted for 22% of energy consumption and 17% of CO_2 emissions [1]. As a result, over the last two decades, a series of policies and regulations have been implemented in order to increase the energy efficiency and reduce carbon emissions. It is estimated that 80% of the current building stock will still be in use in 2050 and current renovations rates of 1% is too low to meet the Green Deal goals [1]. Advances in heating, ventilation, and air conditioning (HVAC) systems, energy-efficiency strategies for the building stock have been advocated to reduce energy consumption in the building sector and encouraging environmental friendly end-use behaviours [2]. These involve improved measures on the envelopes of buildings [3], such as employing innovative materials [4], advanced insulation and building structures [5], new construction and the renovation of existing buildings [6].

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It is well known that, in both residential and non-residential buildings, different types of HVAC systems can be used to control the indoor air temperature, humidity and/or quality [7]. Such parameters significantly affect the indoor thermal comfort [8]. The building thermal comfort level is related to building energy consumption, therefore, a large amount of energy will be consumed while improving indoor thermal comfort [9]. Considering ongoing global warming issues and the increasing demand for cooling energy, it is also important for policy-makers and households to implement suitable strategies to reduce their cooling energy demand and resulting, consequently decreasing the related carbon emissions [10]. In this framework, energy refurbishment actions for the building envelope and HVAC systems are pivotal to reduce the building energy demand. Unfortunately, the majority of these actions are featured by high capital costs and long payback periods. However, significant energy savings can be also achieved simply modifying the users behaviour, avoiding any major refurbishment [11]. Tam et al. [12] argue that the actual occupant behaviour plays a crucial role to achieve an optimal building performance, from both energy and environmental points of view. They also suggest including occupant behaviour in the calculation procedure of the energy rating of existing buildings. A careless behaviour negatively affects the building energy demand, also affecting the thermal comfort. Energy dissipation is often due to a plurality of incorrect user habits. This is especially true in office buildings where occupants are not aware on the impact on the energy bills of their behaviours. Some previous works focused on the promotion of users behaviour change, by encouraging the adoption of positive energy management habits. These behavioural interventions include the use of interactive games to increase the user awareness regarding different energy-saving strategies [13], using monetary rewards to encourage energy conservation, introducing different forms of incentives to motivate the adoption of positive energy management habits [14].

In the framework of the user behaviour, the dress-code plays a pivotal role in the definition of the user thermal comfort [15], and therefore, of the thermal energy consumption. In many working environments (banks, universities, etc), the clothing insulation mirrors the “power” structure within the workplace, representing the symbol of credibility [16], and the dress code overrides the rational thermoregulatory behaviour. In fact, users are often expected to dress in a multi-layer wool suit, regardless of the hot outdoor climate. Corporate dress codes completely extinguish opportunities for clothing adaptation [17]. In these workspaces, the energy demand for space cooling is higher with respect to the case of more informal dressing codes. For example, a suit without the tie allows one to significantly improve the thermal comfort during the summer season. This results in a lower space cooling demand and environmental impact. Considering near-sedentary activities performed in office buildings, where the metabolic rate is approximately 1.2 met, the effect of changing clothing insulation on the optimum operative temperature is about 6 °C per clo (1 clo is equal to 0.155 m^2 K/W). Therefore, removing of a thin, long-sleeve sweater decreases clothing insulation by approximately 0.25 clo and would increase the optimum operative temperature by approximately 6 °C/clo × 0.25 clo = 1.5 °C [18]. The ASHRAE chart indicates that the clothing insulation should be reduced to 0.1-0.6 clo (ideally, 0.3) to maintain comfort at 25.6°C [19], and not at 21.5°C as in the case of 1 clo (to obtain for a standard office activity of 1.2 met, a relative humidity of 50%, an air velocity less than 0.1 m/s, and the air temperature equal to the mean radiant temperature, a Predict Mean Vote (PMV) equal to 0 and Predicted Percentage of Dissatisfied (PPD) equal to 5%). A change in clothing insulation by only 0.2 clo leads to a temperature change of about 1°C in a typical office building [20].

In civil building environments, many researchers have found that changing clothing to acclimate to different climate conditions has been an affordable and efficient method of achieving thermal comfort [21, 22]. Newsham [23] proposes a model to study the effect of different levels of clothing on thermal comfort and energy consumption. The model is applied to an office, located in Toronto, adopting high cooling set-point temperatures in summer and lower heating set-point temperatures in winter. The aim is to detect the clothing factor values suitable to guarantee a PPD index of around 5%. In case of a more flexible and adaptable clothing, the cooling set-point value of 25.55°C is detected. This decreases to 24.35°C for a value of 0.75 clo. However, both set-point temperatures are lower than the value of the dress factor corresponding to a classic formal dress (1 clo). It is worth noting that the space cooling energy demand significantly depends on the aforementioned set-point values, with an annual consumption of 218 kWh in the first case, 275 kWh in the second one, realizing an energy saving of 21%. Wu et al. [24] present a study dealing with an office building in Guangzhou, featured by a hot summer and a warm winter. To perform the study, once a week the office workers carried out a questionnaire regarding the thermal comfort, whereas physical environmental parameters were continuously recorded. For each season, different clothing factors were considered. They conclude that for the investigated weather zone, increasing the set-point temperature in office buildings from 26°C to 29°C would save about 60% cooling energy without thermal discomfort. Schiavon and Lee [25] developed two multivariable linear mixed models considering the clothing as a function of outdoor air temperature measured at 6 o'clock and of indoor operative temperature. These models allow more accurate thermal comfort calculation and HVAC sizing with respect to the common practice of keeping the clothing insulation equal to 0.5 clo in the summer and 1 clo in the winter. For example, the winter median clothing

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insulation in Canada was 0.8 clo when the median winter outdoor air temperature measured at 6 o'clock was−7.5°C. Lakeridou et al. [26] suggest increasing the set-point temperature of the offices of the United Kingdom by 2°C with respect the current set-point values of 22 ± 2°C. They changedthe set-point temperature only for one floor of the building and measured the indoor air temperatures at various locations across the floors. The results of the statistical analysis for all 129 participants suggest that the increase led to the occupants feeling significantly warmer in comparison with the group at lower temperature settings. However, increasing the floor set-point of open-plan areas to 24°C appears not to cause substantial discomfort, even if the actual percentage dissatisfied (APD) in some offices was near its maximum acceptable value equal to 20%. De Dear [22] examines the influence of clothing for two different cases study located in Sydney (Australia), a suburban shopping mall and a call center. The company that operates the call center is based on a strict working dress code from Monday to Thursday, but employees were free to wear casual clothes on Fridays. The daily mean values for all workers of the clothing factors on Friday were significantly higher than values for other weekdays in winter and lower in summer. On Friday, in the Sydney office case study, workers showed their marked preference for clothing not imposed by codes of formality.

1.1. Aim of the work

Although this topic was widely studied in literature, a lack of knowledge regarding the analysis using dynamic simulations is detected. This kind of analysis allows one to control, for each time step of the simulations, the key variables affecting the thermal comfort, considering the users within a whole building-plant simulation system. Considering that the building is a complex system, the energy phenomena occurring are different and continuously correlated: these phenomena concern the features of the building envelope (walls, roofs, windows), the plants for the production of space heating and cooling, the intended use of the zones of the building (residential, offices, hotels), the presence of a large number of people or machines that produce heat. Avoiding experimental investigations, the dynamic simulation analyzes the energy performance of a building with precision and reliability, obtaining consistent estimates. For this reason, the present study is performed using the TRNSYS software, analyzing the actual influence of the relaxation of the dress code on the cooling energy demand and the thermal comfort of occupants. The developed model was applied to a typical office located in Naples (South of Italy) of the University Federico II. The proposal for an extreme relaxation of the dress code will give the opportunity to remove the jacket and tie from the classic formal dress. As a limit case study, the so-called "tropical" dress, consisting of a short-sleeved shirt and shorts, was also analyzed. Note that the hourly dynamic simulation allows one to evaluate the hours of discomfort of the users as a function of the cooling set-point temperature and clothing factor for any day of the summer season. The dynamic simulation model demonstrated its ability to accurately predict the thermal comfort perceptions. In addition, using the dynamic simulation tool, it is possible to properly design the HVAC systems capacity (oversized to respect specific and rigid thermal comfort conditions), and to determine their lower energy demand.

2. Method

In this section the method used to develop the calculations is presented. In particular, section 2.1 shows the model developed to perform the dynamic simulations and the economic, energy and economic analyses; section 2.2 reports the case study considered to run the simulations.

2.1. Model

The simulation model of the office is developed using the well-known tool TRNSYS. It includes a large library of components, which are able to accurately simulate the energy performance of the energy components included in the investigated system. The types included in TRNSYS environment are considered reliable and validated [27]. TRNSYS software is very reliable and accurate for the evaluation of building energy demand [28] and is considered by the scientific community as a benchmark tool to validate the in-house building simulation models [29-31].

Type 56 was selected to model the office. The validation of the whole Type 56 is presented in reference [32]. This component calculates the dynamic energy demand, by considering its 3D geometry (defined in the Google SketchUp TRNSYS3d plug-in [33], the effects of the environmental conditions (i.e. ambient temperature and humidity, solar radiation, etc.) the envelope thermophysical proprieties, as well as all the internal gains (people, lights, machineries), the ventilation and infiltration rate. The office geometry analyzed in this work is represented in

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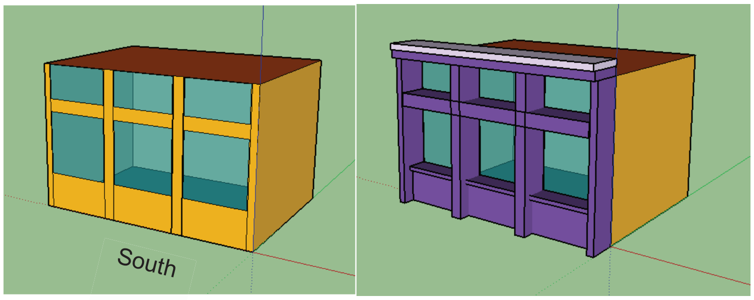
Figure ***1***. Details about the geometry are provided in the case study section. To simulate the external overhangs, the tool "Trnsys3d Shading Group" was used. In Type 56 a number of parameters can be set: material thermophysical properties of walls and layers, ventilation and infiltration profiles, heat gains, heating and cooling scheduling, etc. Note that the mathematical model of Type 56 allows one to evaluate the building user comfort according to the ASHRAE Standard 55-2013 [34]. It is also worth noting that Type 56, included in TRNSYS 18 release, includes a detailed model for the calculation of radiation in the building, taking into account a complex model for the calculation of view factors and considering the radiative properties of the surfaces as a function of the wavelength. As a consequence, the model returns the wall temperatures and the radiate flows emitted by the walls and transmitted by the glazing surfaces. Thus, the model can also calculate important comfort parameters such mean radiant temperature and operative temperature which directly affect the comfort indexes. The most relevant comfort parameters are calculated according to the Fanger theory [35]. In particular, according to the UNI EN ISO 7730 regulation [36], the calculated comfort indexes are Predicted Percentage of Dissatisfied (PPD) and Predicted Mean Vote (PMV). Therefore, the model allows one to detect the number of operating hours where the comfort parameters are outside the acceptability range (discomfort hours).



(a) *(b)*

Figure 1. Sketchup 3D model of the office, without (a) and with (b) external overhangs

Type 15 and 109 were used to simulate the weather conditions of the city where the selected office is located providing the hourly weather data files obtained by Meteonorm database. The cooling energy needed to cool the office at the desired set-point temperature is produced by a fan coil unit, simulated by the TRNSYS Type 600. The fan coil is supplied by chilled water by a suitable variable speed pump, simulated by Type 110. A suitable control strategy, managed by the proportional controller Type 1669, is implemented in the model to manage the water flow rate flowing through the pump. The controller manages the flow of water to be supplied to the fan coil according to the indoor air temperature of the office. When the indoor air temperature is higher than a fixed threshold value, the pump supplies the fan coil with the highest value of flow rate, which is proportionally reduced when the indoor air temperature decreases. The fan coil air flow is assumed to be constant, and it depends on the nominal cooling capacity of the fan coil.

2.2. Case study

The case study is a 22.3 m^2 office located at 10th floor of the building of University of Federico II, in Naples, South of Italy, see

Figure **2**. The office consists of one external vertical wall and three adjacent vertical walls, bordering other internal areas (offices and hallway). The building. On the external wall there are six double-glazed windows with aluminium frame and air gap.

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(a) (b)

Figure 2. University of Federico II, Piazzale Tecchio, Naples, Italy (a), Investigated Office (b)

In particular, three windows (1.52m x 1.56m) are located on the lower side of the wall and three windows (skylights, 1.52m x 0.85m) are located on the upper side of the wall. The aluminium frame covers 35% of the whole glazed area for lower side windows and 40% of the whole glazed area for upper side windows. A venetian blind is also considered for all lower side windows, device that plays a fundamental role in calculating of the incoming solar radiation. To control the opening and closing of the shading device, a suitable control strategy of the solar radiation is implemented. In particular, if the total horizontal radiation is lower than a certain treshold, the shading device is completely opened. Conversely, the shading device is completely closed.

The building envelope was defined according to the period of construction of the building. The features of the typical buildings constructed during the years from 1955 and 1970 were assumed and reported in Table 1.

Table 1. Thermophysical proprieties of the office

Component	Thickness [mm]	U [W/m^{2}K]
Internal floor/ceiling	350	0.347
External wall	340	0.326
Outer pillar	470	1.899
Window glass (lower and upper wall)	4/16(air)/4	2.89

The heat gains due to the people, lighting systems and machineries were summarized in Table 2. The considered values were fixed according to the ASHRAE Handbook Fundamentals [37]. The infiltration rate was set equal to 0.6 1/h. The office is occupied by users from 9:00 am to 6:00 pm on weekdays. The closure of the office during the summer holidays was assumed from August 8th to 22nd. The cooling season was assumed from May 1st to September 30th. The cooling system operates only during the occupation hours.

A control strategy related to the switching on and off of the artificial lights was implemented. Easily, the lights are switched on when the total horizontal radiation is lower than a fixes value defined equal to 120 W/m^2.and switched off when it is higher than 200 W/m^2.

Table 2. Heat Gains

Mode	Total heat [W]	Radiative heat [W]	Convective heat [W]
Two computers			
Continuous operating	65	6.5	58.5
Energy saving	25	2.5	22.5
Four Monitors, 48 cm each one			
Continuous operating	80	8	72
Energy saving		0	
Lights: 2 LED panels [60cmx60cm] 48W			
Switching on	31.2	8.4	22.8
	Two women	Activity: Light office work	
Total heat [W]	Sensible heat [W]	Latent heat [W]	Radiative Sensible heat [%]
115	70	45	60

For the comfort analysis of the office occupants, three different combinations of the main variables affecting on the thermal comfort condition were simulated.

In particular, the metabolic activity and air velocity values were set constant and equal respectively to 1.2 met (representative of the light metabolic activity for sedentary office work) and 0.1 m/s. Such values are consistent with the type of simulated indoor environment. As for the clothing factor, three different values were defined, each corresponding to a specific outfit. In particular, according to the EN ISO 7730:

- For the comfort condition C1, the value of 1 clo was associated, representative of the classic formal dress (trousers, long-sleeved shirt, jacket and tie);
- For the comfort condition C2, the value of 0.5 clo was associated, representative of a generic light summer clothing (light trousers and unbuttoned short-sleeved shirt);
- For the comfort condition C3, the value of 0.3 clo was associated, corresponding to a "tropical" outfit, consisting of shorts, a short-sleeved shirt, socks and sandals.

Concerning the energy, environmental and economic analysis, the following assumptions were considered. To convert the cooling energy demand of the office in electric energy, a constant coefficient of performance equal to 3 [38] and an electric efficiency of the national power plants equal to 0.46 [39], were assumed. The operating cost evaluation is carried out assuming a specific electric unit cost equal to 0.53 €/kWh$_{el}$. The total CO_2 emissions due to the electric energy demand were evaluated considering an equivalent emission factor equal to 0.48 $kgCO_2$/ kWh$_{el}$ [40].

3. Results

In this section, the main results obtained by the dynamic simulations are discussed. The results are presented considering the hourly trends over a single day of the summer season as well as the energy trends obtained for each month of the summer season. The results obtaiened by a sensitivity analysis, performed by varying both the set-point temperature of the cooling plant as well as the clothing factor of the users are presented, considering their effect on the thermal comfort of the users itself. Note that for the comfort analysis, it was assumed that the user perceives a comfort condition according to the values assumed by PMV. If $-1 < PMV < +1$, the user perceives a comfort condition.

In

Figure ***3***, the hourly trends of the main physical parameters (relative humidity and radiant mean temperature) affecting the thermal comfort of the users (according to the UNI EN ISO 7730) are reported for a typical summer day. The air velocity was assumed constant at the value of 0.1 m/s, considering that in the investigated office no significant inflitration occurs. Note that both graphs of

Figure ***3*** report such trends for all the considered set-point temperatures of the cooling plant (from 24°C to 28°C).

For all the set-point temperatures similar trends of the mean radiant temperature can be observed. In particular, the mean radiant temperature decreases from 00:00 to 06:00 am following the trend of the outdoor air temperaure and it starts to increase from 06:00 and 09:00 am, when the sun rises and the solar radiation is directed on the external wall of the office. When the cooling plant is switched on (from 09:00 am to 6:00 pm), the radiant mean temperature decreases. The drop is more significant for the set-point temperature of 24°C Note that the office consists of one external wall and its windows all facing south. Therefore, although the indoor air temperature reaches the set-point value, the radiant mean temperatures increase reaching the maximum values at 12:30 pm, due to the high solar radiation incident on the office. For the set-point temperature of 28°C and 24°C, the radiant mean temperatures reach the values of 29°C and 26.5°C, respectively, although the cooling plant is switched on. The lowest peak values achieved at 06:00 pm occur at the closing time of the office and the switching off of the cooling plant. After that, the radiant mean temperature shows again an increase, due both to the solar heat which is absorbed during the day and released during the evening hours, and to the radiative and convective fluxes emitted by the computers which continue to be active in the energy saving mode. A slight reduction of radiant mean temperatures is verified during the late afternoon and evening hours when the solar radiation is zero and the outdoor air temperature starts to decrease. For all the set-point temperatures similar trends of the relative humidity can be observed. In particular, it is about lower than 70% during the office opening time, while it shows significant increases in the first and last hours of the day. Note that the cooling plant reduces the relative humidity of the investigated office but it is not designed to constantly control the relative humidity of the room. Therefore, for a typical sunny and humid day as the reported one, the relative humidity is high during the operation hours. However, the values fall within the range 30%-70%, suggested by the UNI EN ISO 7730.

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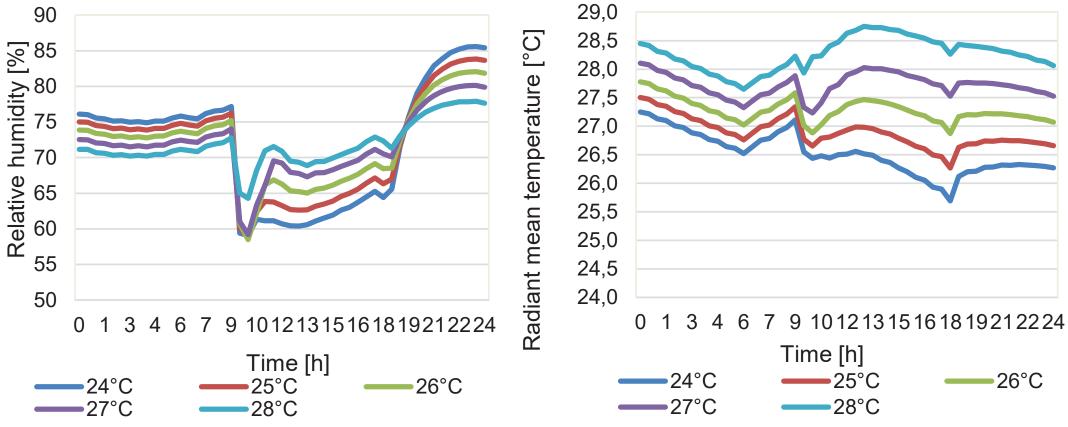

(a) *(b)*

Figure 3. Hourly relative humidity (a) and radiant mean temperature (b)

In Figure 4, the monthly cooling energies from the cooling season (May-Sept) for all the investigated cooling set-point temperatures were reported. Considering the weather data of Naples, the hottest month is July. In this month the highest consumption for space cooling purpose is equal to 18 kWh/m^{2}month for the set-point temperature of 24°C. The lowest one is equal to 12 kWh/m^{2}month for the set-point temperature of 28°C, 33% lower than the previous case. Note that the low peak values occur in August are due to the two closing weeks of the university for the summer vacation.

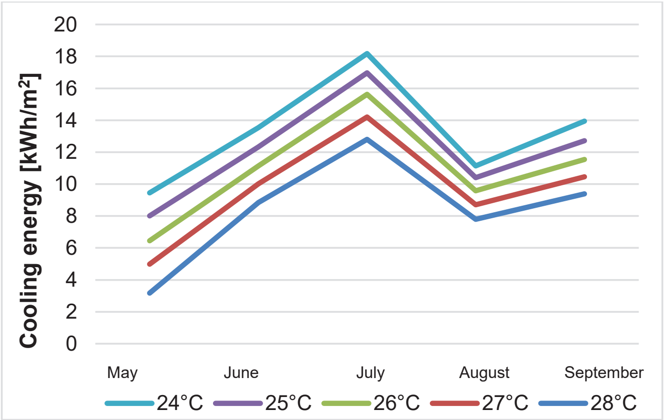

Figure 4. Monthly cooling energy vs cooling set-point temperatures

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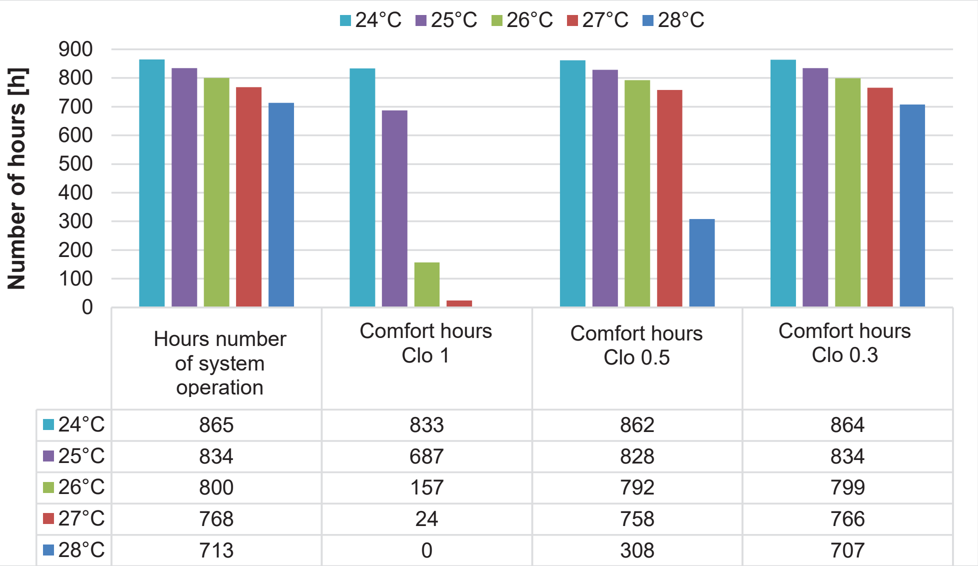

	Hours number of system operation	Comfort hours Clo 1	Comfort hours Clo 0.5	Comfort hours Clo 0.3
🟦 24°C	865	833	862	864
🟪 25°C	834	687	828	834
🟩 26°C	800	157	792	799
🟥 27°C	768	24	758	766
🟦 28°C	713	0	308	707

Figure 5. Comparison between hours of plant operation and hours of comfort

Figure 5 shows the comparison between the hours of plant operation and hours of comfort for the three considered scenarios of clothing factor, equal to 0.3 clo, 0.5 clo and 1 clo. As the set-point temperature value increases, the number of operating hours of the plant progressively decreases from 865 to 713. In the case of the classic formal dress, see CLO 1 scenario, the number of operating hours of the plant is high only at 24°C, whereas it is equal to 0 and 24 at 28°C and 27°C, respectively. With light summer dress, see CLO 2 scenario, the number of operating hours of the plant is high up to 27°C. With a tropical outfit, see CLO 3 scenario, also the cooling set-point temperature of 28°C becomes tolerable, considering that the number of operating hours of the plant is 707. The cooling set-point temperature of 28°C is not suitable for clothing factors equal to 1 and 0.5.

In Figure 6 the frequency distribution of PMV related to the number of plant operation for different cooling set-point temperatures were reported. Considering a clothing factor equal to 0.3 and a set-point temperature of 24°C, the PMVs are for about 850 hours lower than 0. For about 100 hours, a cooling perception, corresponding to $-0.75<PMV<-1$ was observed. Considering a clothing factor equal to 1, only a very low number of hours corresponds to PMVs higher than 1. For a set-point temperature of 25°C and a clothing factor of 1, for more than 150 hours, the obtained PMVs are higher than 1. For the same clothing factor, an increase of the set-point temperature of only 1°C determines a very significant increase of the discomfort hours, passing from about 150 to 650 hours. For a set-point temperature of 27°C and a clothing factor of 0.5, related to the summer light dress, almost all the PMVs are lower than 1 for all the operation hours. However, if the set-point temperature is raised to 28°C, for about 400 hours the PMVs are higher than 1. Conversely, if a summer light dress is adopted, i.e. a clothing factor equal to 0.3, all the PMVs are lower than 1 for all the operation hours. This means that the relaxation of the dress code is functional for the reduction of the cooling energy consumption, considering that the users will set a high cooling temperature due to the cooling perception due to the adoption of summer light dresses.

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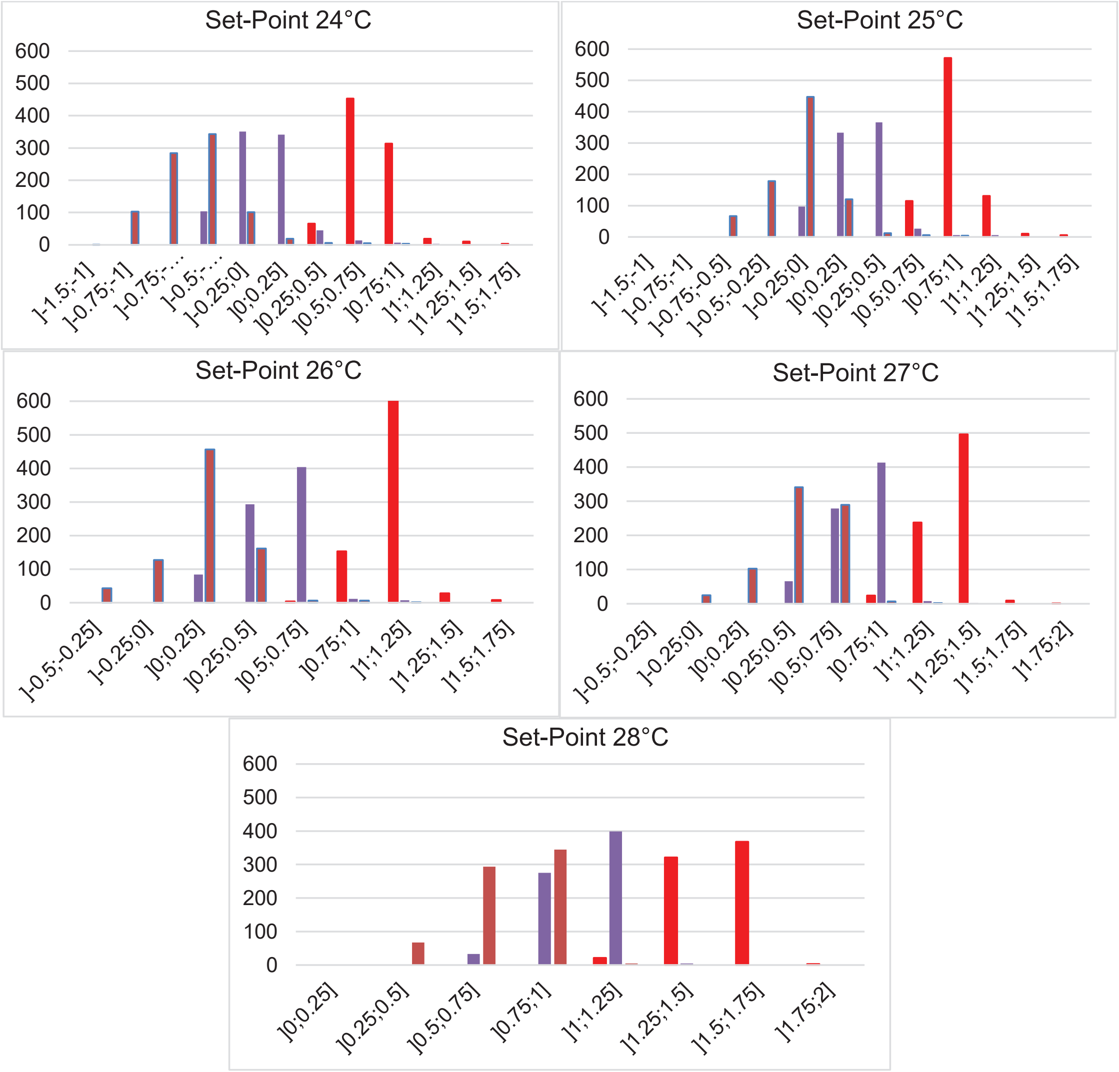

Set-Point 24°C

Set-Point 25°C

Set-Point 26°C

Set-Point 27°C

Set-Point 28°C

Figure 6. Frequency distribution of PMV indices for different cooling set-point temperatures

In Table 3, the results of the energy, economic and environmental analyses for all the set-point temperatures investigated, from 24°C to 28°C were reported. A set-point temperature of 24°C involves a cooling energy demand of 66 kWh/m^2 higher than the energy demand related to the set-point of 28°C, equal to 42 kWh/m^2 and higher than the demand related to the value of 26°C, equal to 54 kWh/m^2. The set-point temperature of 28°C and 27°C, determines primary energy savings over 32%, when compared with the set-point temperature of 24°C. The set-point temperature of 28°C corresponds to a reduction in the total CO_2 emissions of 108 kgCO_2/year when compared with the set-point temperature of 24°C. Concerning the operating cost for space cooling, for the set-point temperature of 24°C, the obtained value is 376 €/y, which reduces to 252 €/y for the set-point temperature of 28°C. Therefore, without any capital cost, this energy measure, simply wearing a tropical or light summers dresses, can be useful for reaching important energy, economic and environmental savings. Note that this energy measure was evaluated only considering one office of 22 m^2. Therefore, the results could be of course more advantageous and significative if the analysis will be extended to other offices of the university.

Table 3. Energy, economic and environmental analysis

Set-point temperature [°C]	Cooling energy [kWh/m^{2}y]	Primary energy [kWh/m^2 y]	Cost for space cooling [€/y]	Total CO_2 emissions [kgCO_2/y]	Increase of cooling energy [%]
24	66.24	67.60	376	332	57.80
25	60.41	62.34	347	306	43.92
26	54.35	56.81	316	297	29.47
27	48.36	51.24	285	252	15.21
28	41.98	45.32	252	224	-

4. Conclusion

This study evaluated the influence of classic formal dress-codes on the cooling energy demand and the perceived comfort, in office users during the summer season. A typical university office was selected to evaluate which effective consumption reduction could be obtained through a significant relaxation of the dress-code, when an increase of the air set-point temperature occurs. Several clothing factors were considered related to the classic, tropical and light summer clothing. The investigation was performed in TRNSYS environment by a dynamic simulation model evaluating both the common comfort indexes and the cooling energy demand of the office. The model was applied to a suitable case study, the office room located at the University of Naples Federico II, where authors of the presented study work. The results of the simulations showed that the clothing factor and the set-point temperature dramatically affect both energy consumption and the comfort indexes values. Furthermore, these results proved that the use of a more flexible dress-code, considering higher set-point temperatures, significant energy, economic and CO_2 emissions savings can be obtained. The increase of the summer air conditioning set-point temperature up to 28°C, is acceptable only for the dress code consisting of shorts and short-sleeved shirts. If this clothing is extreme and unacceptable for the type of office considered, a more formal dress-code, consisting of trousers, a short-sleeved shirt and closed shoes, can be adopted. However, in this case the increase in the air set-point temperature up to 27°C can be settled. If any relaxation of the dress-code can be accepted due to the fact that the classic formal dress is essential for the users, acceptable comfort index values can be obtained only if the air set-point temperature is decreased at least 24°C. This value not only is lower than the threshold set by the Italian normative (DL 1 March 2022, N. 17) regarding the summer air conditioning temperature, but also implies energy, economic and environmental impact increases. A set-point temperature of 24°C is the only value compatible with the classic dress, although this involves intolerable cooling energy demand. The set-point temperature of 27°C, compatible with light summer dress determines cooling energy savings over 37%. The set-point temperature of 28°C is compatible only with the tropical dress. and corresponds to a reduction in the consumption of cooling and primary energy by over 50%.

The analysis of the case study allowed, albeit on a small scale, to test the high potential of the increase of the cooling set-point temperature in the offices during the summer season, on the significant reductions in terms of energy, economic and environmental impacts. However, there are critical issues, which risk limiting the implementation of the initiative.

- Workers that may not feel adequate with a more flexible type of clothing and are still anchored to the choice of a formal outfit because it is coherent with the company policy.
- The difficulty of implementation within working contexts that require the interfacing with the public, considering the common idea that the dress worn reflects the degree of seriousness, reliability of employ, of professionalism and competence within a working context.

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