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1 Executive Summary

The objective of this report is to present the establishment, monitoring of and initial results of the Cyprus demonstrator. This deliverable D5.3, with introductive information on E-DYCE demonstrators and their methodological organization reported in D5.1, defines the current state of Cyprus demo buildings and prepares the subsequent data analysis step that would be collected in the deliverable D5.6.

The Cyprus demonstrator comprises a group of 4 similar office buildings located in Nicosia historic city Centre, a stone throw of the green line separating the City in two as a result of the war. It is a new energy class A building designed with passive strategies. The global energy consumption analysis includes the whole complex, while the comfort, indoor air quality analysis and simulation is concentrated on one building.

Section 2 describes the bioclimatic measures implemented in the building. A well shaded building, naturally ventilated, with high thermal insulation levels and thermal mass. The presentation includes description of the design process considering the climate particularities and the user's wishes.

The monitoring plan is described in section 3. A representative office building is equipped with low-cost commercial all-public indoor environment quality sensor. Activation of existing sub-metering of electricity consumption made it possible to connect the Cyprus demonstration case on the cloud and FusiX with relatively low cost.

Section 4 focusses on the inspection of the building, using a special interview method borrowed from cognitive sciences. The clinical method of interviewing the building users, consist of a free, structured and prepared interview, leaving the subject to express his or her perceptions with less influence from the analyst. This method reviled interesting findings how users perceive thermal comfort, their motivations and rituals for window openings, and many proposals for the building optimisation or critics on the building design.

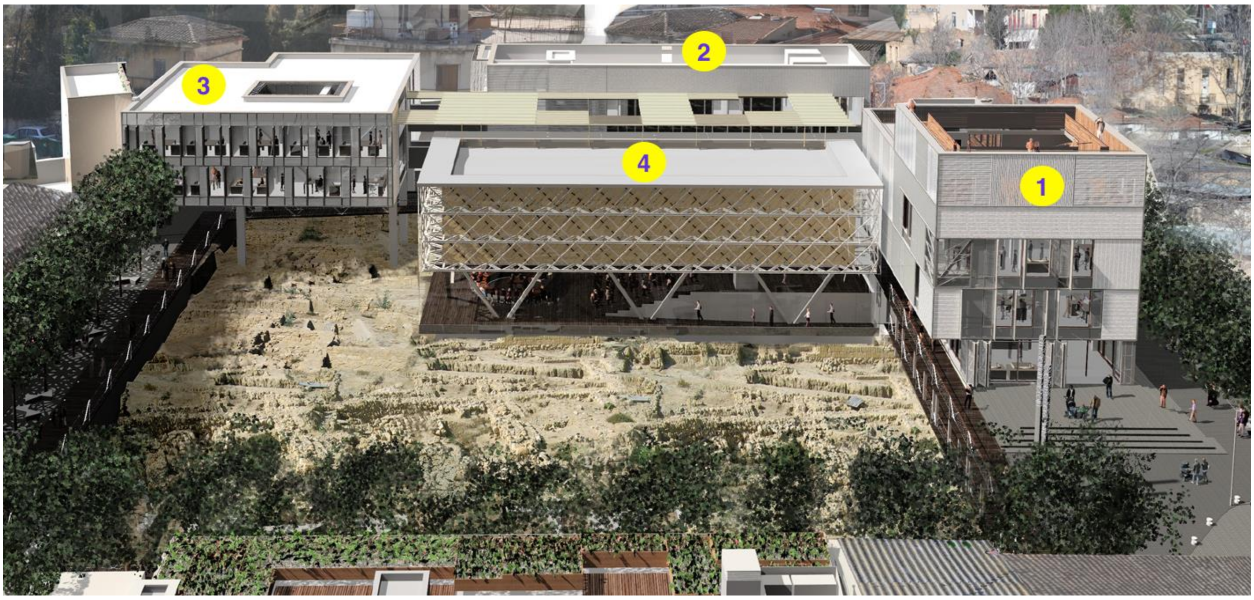
Section 5 presents the results of energy consumption and compares the with the EPC expected values showing that the building in 2021 managed to become a real class A building. Before E-DYCE monitoring, the building was experiencing an undetectable performance gap of 170% and with a simple routine maintenance the technical services brought energy consumption to the designed expected values preparing the demonstration case for a real optimisation using DEPC analysis. Comfort key performance indicators analysis showed an exceptional air quality provides by well-designed natural ventilation and comfort analysis showed the general satisfying big picture but also optimization potential for particular problematic premises.

Section 6 describes modelling and preliminary results comparing EPC with DEPC and real measurements, to finish with section 7 with the conclusions and the following steps including the optimization proposals to the users. The simulated and real effect of their implementation is going to be evaluated in the second face of the project. The design passive choices and possible alternatives are also to be evaluated using the DEPC simulation framework.

2 Description of Cyprus case study

Nicosia Town Hall is one of the first green modern passive buildings in Cyprus. It was designed by irwinkritioti. architecture. Building physics was designed by Estia SA and the owner is Nicosia municipality. It is a group of buildings, and the main core is composed of 5 buildings. 4 of them are ordinary office buildings and one is an emblematic building that with approximately total building capacity of up to 200 people. E-DYCE analysis will concentrate on the office buildings which are similar in design. The building complex is situated in the historic city centre, very near to the green line separating the town because of the war.

New Nicosia Town Hall is not just a green building that incorporates many green design principles. It is the first project in Cyprus where all the bioclimatic design principles needed for the building to be of energy category A are present. It requires/demands for heating, cooling, ventilation, hot water, and lighting less than 58 kilowatt-hours of electricity for each square meter to operate instead of the 150 - 400 that conventional public buildings consume in Cyprus. Such a building is called passive because without mechanical equipment, without moving or burning anything to support it, it requires minimal energy for thermal comfort, ventilation, and lighting. It is a very good “free-running building” case study, and this is the reason that it was selected to test the E-DYCE principles.



The bioclimatic shell of the building is not only an aesthetic composition that tries to fit into the environment of the old town and the antiquities it its basis. It is equivalent to hundreds of m^2 of photovoltaics that we do not need to install. We call this building passive because no mechanism is moving to produce the energy drawn from the immediate environment of the building. You do not need to go to Saudi Arabia or the Cyprus Venus plot for pumping gas to make it run. You can draw it from the natural elements surrounding your building in the centre of Nicosia. Almost all the heat for heating in winter is provided by the sun, and the shell is insulated so we do not lose absorbed energy. One-third of the cooling for the summer is provided by the cool night breeze of Nicosia. The clear Nicosia sky provides 80% of lighting. The fresh clean air is not-channeled by machines and fans passing air through ducts and other air processing devices but by the wind and the natural thermodynamic movement of the air.

The building is a tool for the city to better serve its citizens. It is also a place of employment for hundreds of people. Before the design went forward, designers circulated a questionnaire to all city employees and incorporated their preferences into the specifications of the technical solutions. More than 70% of employees prefer physical comfort rather than full air conditioning, bright offices, quietness, and the ability to concentrate at work, places where they can take a coffee or lunch in a pleasant environment.

All standards for people with mobility problems are met. A green building has the first role to serve people. The materials used are not only environmentally friendly but also human friendly. There are no adhesives, synthetic materials, carpet, synthetic paints and varnishes or other harmful chemicals in the building to emit synthetic particles that could be breathed in by the residents.

The project's construction costs are within the typical office building costs. However, the cost of maintenance and operation will be much lower. A passive building is technically sober. The more sober it is, the less maintenance it needs. Natural ventilation has neither operating nor maintenance costs and only requires minor maintenance cleaning and checking after many years.

List of 15 measures taken in the green design of the new town hall

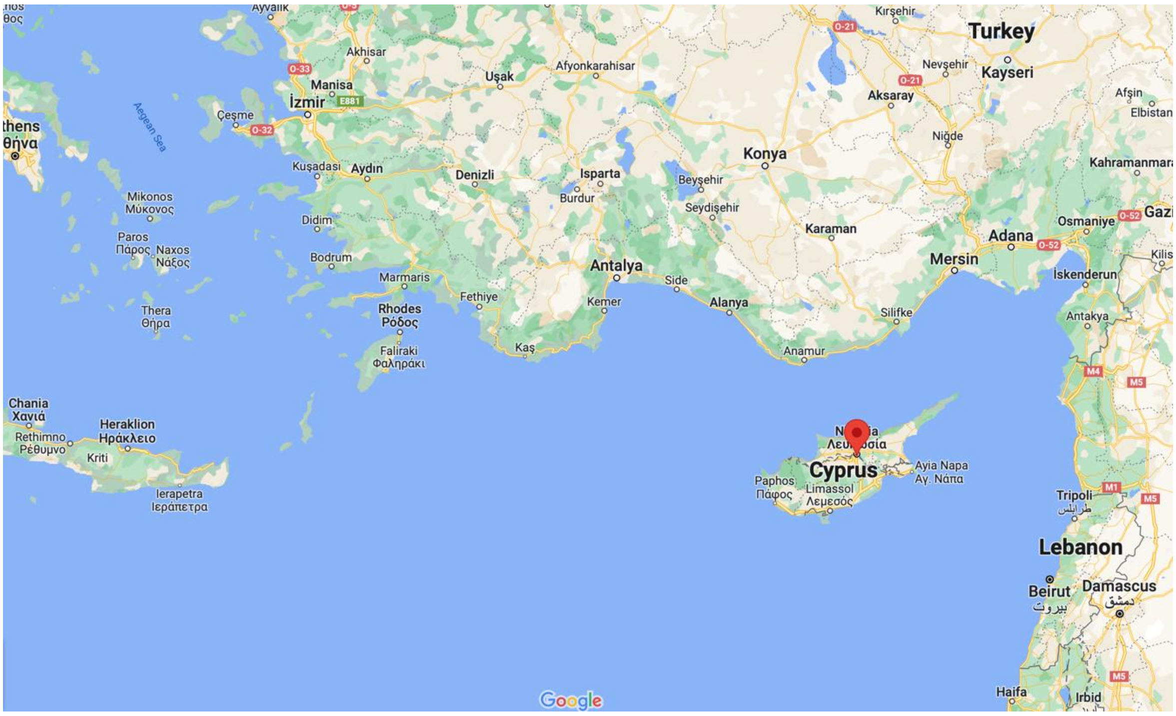
- 10 cm thermal insulation stone wool on the roof and facades and reduction of thermal bridges
- Optimum geometry and opening position and dimensioning
- Optimum preferably passive shading and dynamic where necessary
- Selection of glazing low u value (1.3 W/m2K) and optimum g value (0.44).
- Night ventilation in summer
- Natural ventilation designed to respond adequately in all seasons
- Maximisation of thermal mass.
- Installation of ceiling fans
- Installation of high-efficiency VRV air conditioners (COP 4.5-5.5)
- Choice of light colours on walls and ceilings for efficient natural lighting
- Maximization of the light transmission of glazing
- Exclusion of staircases and common areas from the envelope
- Use of high-efficiency luminaires
- Use of automatic electrical switch and automatic lighting management.
- Use of environmentally friendly materials with low embodied energy

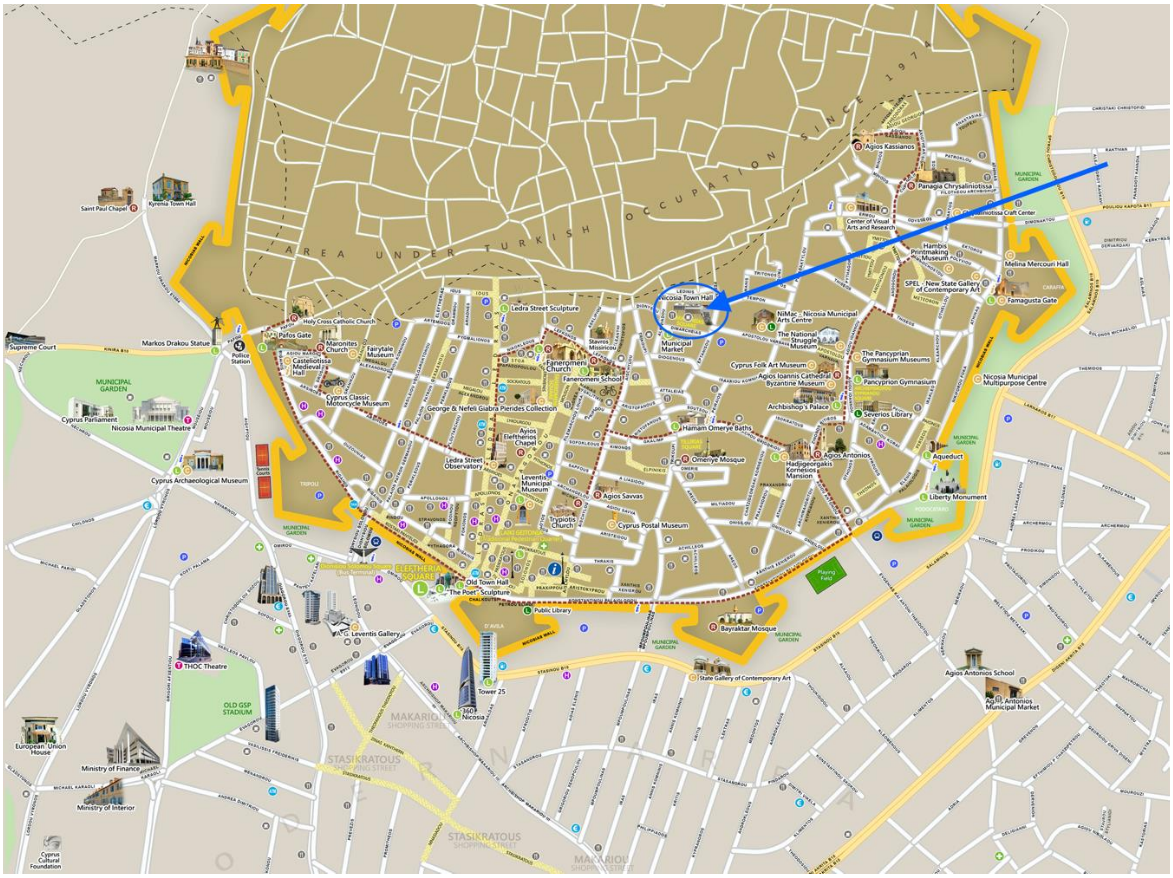
Most of these passive strategies, especially those acting on the building dynamic behaviour are not considered in the EPC calculation framework: night ventilative cooling, presence of ceiling fans, natural lighting, partial cooling, and heating by excluding large parts of the building from the conditioned area, dynamic ventilation according to use and external climatic conditions.

The reason we selected this building for E-DYCE is to evaluate the real efficiency of these passive technologies through monitoring and dynamic simulation, to understand the free running real behaviour of the building and its impact on comfort and adapt the E-DYCE approach to real free running buildings.

2.1 *Geographic and climatic context*

Cyprus is situated in South-Est Mediterranean. Nicosia is situated in the centre of the island with a hot and dry climate in summer and relatively cold for the region winter. Nicosia townhall is situated in the centre of the historic city near the green line separating the city.





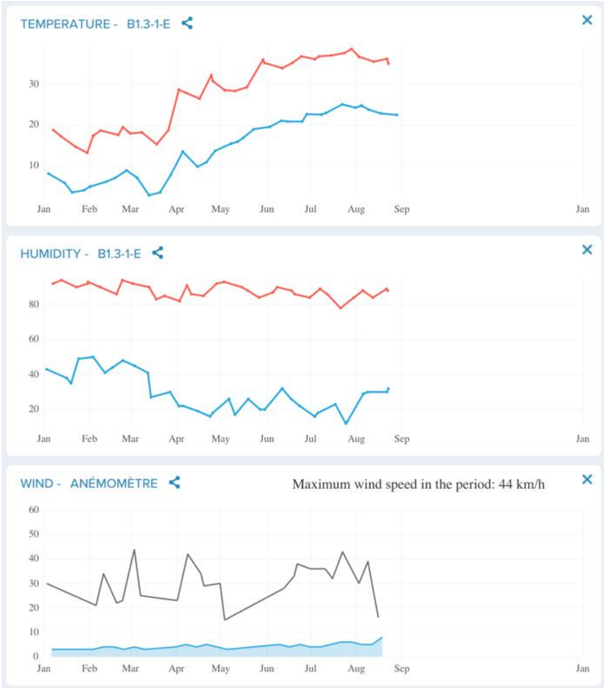


Figure 1. Max end min temperature, humidity, and wind profile on site during 2022.

Figure 2. Typical week in winter (14-21 Feb 2022) and summer (4-11 Jul 2022)

Although in the population's mind summer temperature during day is 35-40°C as we can see on the graph of 2022 measured meteorological data show that extreme temperatures are not so often and during heat waves extreme temperatures are only for few hours. We can see also a significant free cooling potential during night even in July with temperatures below 25°C. We also observer a significant wind potential making cross ventilation interesting during hours where outside temperature is near comfort.

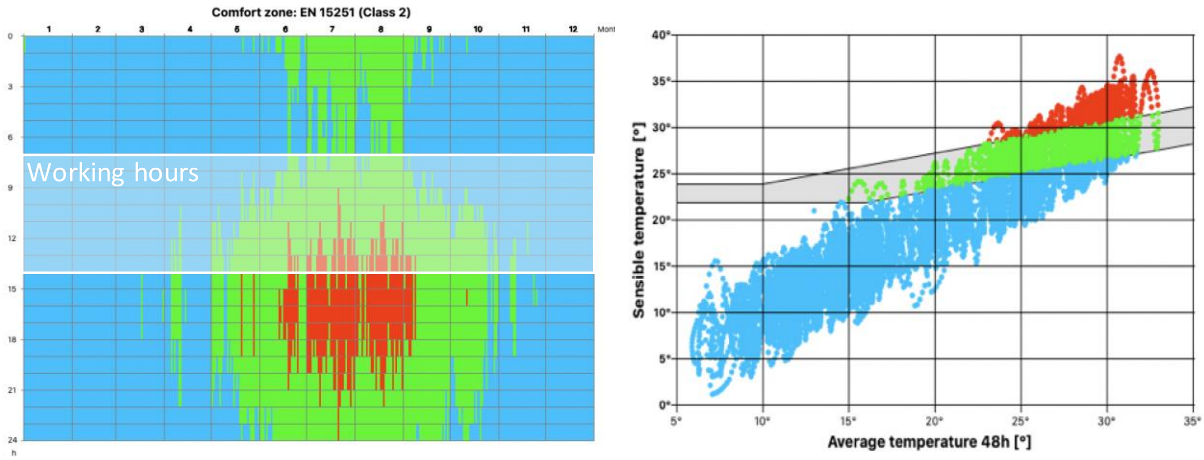


Figure 3. Outside temperature plotted on EN15271 comfort time chart and on sensible instant temperature vs average temperature, showing 825 hot hours, 1745 comfortable hours and 6190 cold hours.

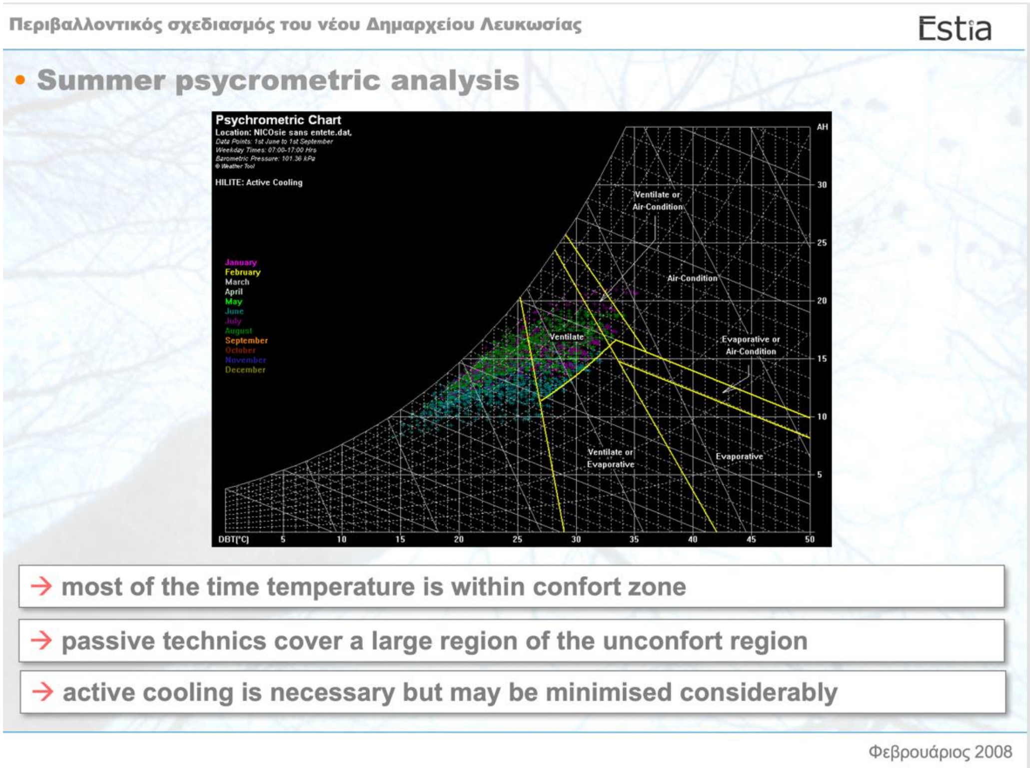


Figure 4. We found in the design archives an analysis of the local climate on a psychrometric with recommendations of the building physicists to the architect orienting to passive ventilative cooling.

As we see on the graphs of the meteorological data, even in extreme Mediterranean hot climates in summer and relatively cold in winter there is a significant potential for passive strategies. As we observe also on the time chart the higher concentration of comfortable hours are during the working hours. Until 11 in the morning there is rarely an overheating time window. This was fully exploited by the design team and as we see on an internal technical report we found in the project archives, the building physicists were recommending passive techniques like insulation and solar gains in winter and insulation, solar shading and passive cooling during day and night.

2.2 Bioclimatic design of the building

The "town hall" is not a single building. Archaeological findings restricted the available land to the 1/3 of the initial available surface and the unique initial building is split to smaller units to fit in the remaining complicated site. 4 office buildings and a municipal hall, able to receive the council meetings in presence of 250 people, form a neighbourhood in Nicosia old town.

According to the designers, bioclimatic and sustainable architecture started from the site use. The buildings respect the old town scales, and they are integrated in the archaeological site not only preserving cultural heritage, but also making it available to the population, through walk paths, squares, and shaded patios. They create a public space with a social environment, where urban life meets culture and municipal services, in a marginalized district of the city, where social life is stopped for many years now after the war the separation line dividing the town. Orientation and disposition of the buildings group similar uses, separate polluting and noisy activities from office spaces, create natural shading to public space and neighbouring buildings.

Figure 5. Instead of a single building occupying the whole land, a group of small buildings around the archaeological findings create interesting bioclimatic potential.

Figure 6. In these virtual views produced during design we can already see the intention of the architects to benefit from mutual shading of the buildings or shaded bioclimatic squares.

Generally architectural strategies are completely ignored from EPC approach. Mutual building shading is considered in solar gain calculation as well as the orientation of the windows. However, externalizing circulation and secondary use surfaces from the heated zone are not considered. Specific energy consumption determining the building label is calculated based on the heated and cooled area. If we zoom on the building drawings, we may see that on the West there is only one window, and the left of the facade is opaque wall. The West staircase, additionally to its shading function it is left outside the heated zone. In a climate like Cyprus climate, there is no heating or cooling in circulation spaces. On the east façade, we have 40% of the surface opaque and the glazed part is partially shaded by an adjoining building which is non heated. Its façade is a green façade. The functions in this building are polluting functions like heavy duty printers, toilets, and staircases. Building 3 is constituted by 953 m^2 of heated area and 208 m^2 of external area. 18% of the useful area is free running without any air conditioning machine saving investment, maintenance, embodied and operational energy. Furthermore, VOC from printers or cleaning chemicals for the WC are not emitted in the living space.

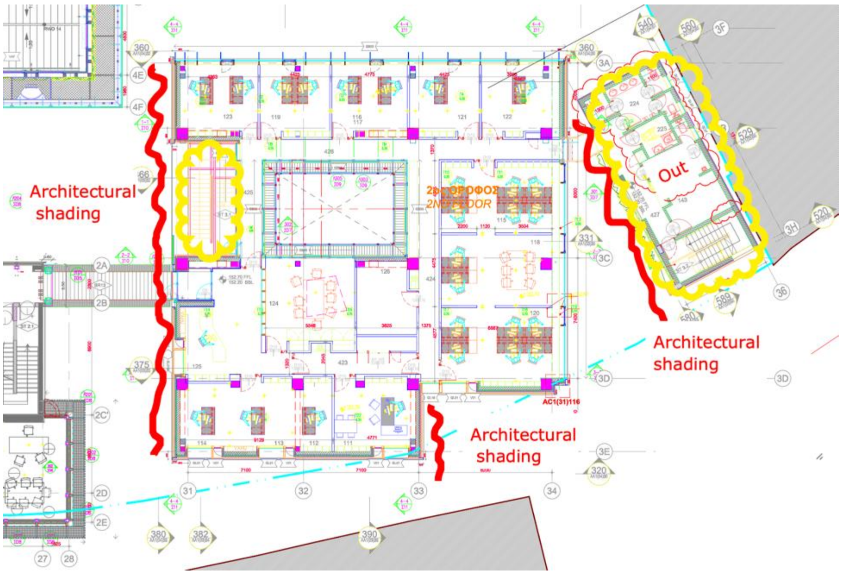


Figure 7 Architectural shading and large spaces left outside the heated or cooled zone.

2.2.1 Consulting the occupants before design

Figure 8. 30% of the occupants declared not having enough control in their indoor environment, 45% were feeling confined in their previous offices and 85% considered extremely important to have openable windows.

Many of the design choices were determined by the occupant's preferences. There were for example serious discussions for the choice between natural or mechanical ventilation with heat recovery. The opinion of the users played a role for the decision complementary to energy calculations and life cycle assessment of the two systems. Bioclimatic characteristics of the site were in favour of natural ventilation and the user's preference also. Natural ventilation and duct absence gave more freedom to the architectural design.

In general, the municipality personnel were very unhappy in the previous offices. High percentage of discomfort feeling, cold droughts, bad air quality, high building syndrome index.

2.2.2 Building envelope thermal quality

In 2008, concepts like "near zero energy buildings", EPC's or even thermal regulations were inexistent in Cyprus. However, the municipality wish was to have a very high energy performance building.

After several optimisation dynamic simulations with DIAL+ software, we decided that the optimum insulation characteristics to meet the passive standards are 10 cm of rockwool for the roof and the facades, 5 cm for the periphery of the building and a U value of the windows of 1.3 W/m^{2}K. Thermal insulation on the ground does not change anything, as the mean ground temperature in Cyprus is high. A careful analysis and treatment of every joint between constructive elements minimises thermal bridges and heat losses in winter. External insulation gives the advantage of thermal mass inside the building.

Figure 9 Outside thermal insulation with minimised thermal bridges is composed mostly by 10 cm rockwool. Foundations are insulated with 5 cm xps. In some special cases it was necessary to use internal thermal insulation with 10 cm rockwool.

2.2.3 Thermal mass

An apparent cladded concrete ceiling and a floor composed with 4 cm anhydride screed over the concrete slab and rough concrete screed, offer a high thermal mass, absorbing excess heat during the day and restoring it during night. This optimises the use of internal heat gains during winter and reduces the pick temperature during summer.

Figure 10. Floor and ceiling are composed by massive materials with high thermal mass

2.2.4 Solar shading

The south façades (15° South – West) at 14:00 is shaded with 60 cm static top and side solar protection. The choice of a glazing with g value of 0.4 is a good compromise between summer solar protection and winter useful solar gains. The façade white ceramics is a robust, inert, self-cleaning material with low sun absorption, offering low façade temperature rise to prevent overheating of incoming air during summer. The table shows the solar shading during the year. In winter solar shading is minimum and in summer maximum. However, in mid-season without additional shading there are glare problems and solar gains could be too high, so a very reflecting internal blind is completing the static shading.

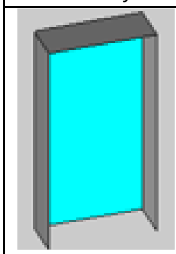
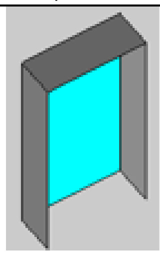
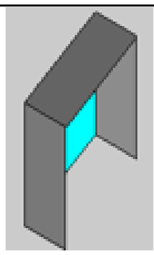
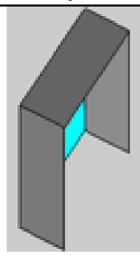
1st February	1st April	1st June	1st July
			
24 %	48 %	88 %	91 %

Figure 11. Static solar shading of the South façade (15° West).

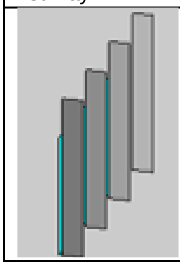
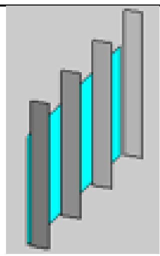
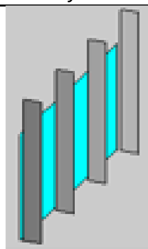
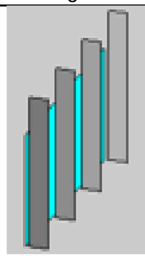
1st May	1st June	1st July	1st August
			
86 %	60 %	57 %	74 %

Figure 12. Static solar shading of the North façade (15° East).

As the north façade is 15° oriented East, early in the morning during June and July, sun hits the façade for 2 hours – 05:00 – 06:00. Some solar shading is necessary to protect north offices early in the morning. The table shows the shading efficiency of a 60 cm vertical static solar protection at 6 h in the morning.

In all East and West exposed windows there is a movable fabric solar shading functioning manually.

2.2.5 Natural and artificial lighting.

In a context where air conditioning represents ¾ of the total energy demand, internal gain control is capital. Lighting counts for around 50% of the installed electric power. The question is how many hours the users will need to turn it on. High natural lighting autonomy is easy to obtain in a climate with 300 days of sunshine per year. The designer should even pay attention so that there is not excessive light coming from windows. A delicate equilibrium should be found between daylight needs, winter solar gains for passive heating and summer solar gain control. A north office of 4 m large has 2 modules of glazing of 140 X 300 (70% glazing), while a south oriented one a single module of the same dimensions (35% glazing).

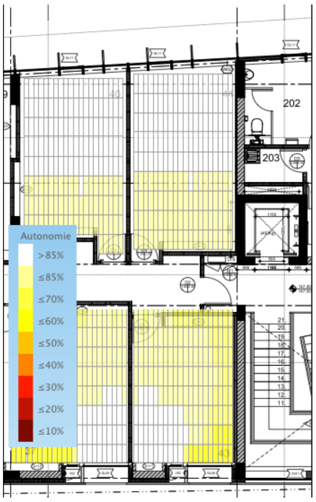


Figure 13. Natural light autonomy, simulated with DIAL+ software between 75 and 85% during working hours.

Several optimisation measures increase up to 30% the natural light autonomy: white colour walls and ceiling; reduction of glazing frames and rise of the window top, up to the ceiling; white colour external shading; glazing with high luminance transmission (g value 0.4, LT 0.7); light wash of the lateral white wall with the glazing moved to the side; These measures provide a natural light autonomy between 70 and 85% during working hours

In addition to natural light maximisation, artificial lighting uses high efficiency luminaires with installed power < 12 W/m^2. Light is automatically switched off when the office is empty.

2.2.6 Natural ventilation design and ventilation strategies.

The building designers concentrated their efforts to design a smart, simple, and user-convenient window. This window should provide easy and intuitive control for limited ventilation during office hours and high airflow rate ventilation during night in summer. In addition, users should not think how to ventilate; they have just to open a window. The opening should be protected, to control the risk of intrusion by undesirable people, animals, insects rain and dust. People should feel safe to leave the vents open during night without any concern.

Vents are vertical, opening on the whole room height, to maximise stack effect. With 5°C temperature difference between inside and outside, a 40 by 300 cm vertical vent creates a stack effect of 611 m^3/h, while the same vent in horizontal position 300 by 40 cm creates only 223 m^3/h. The right disposition of the vent opening may boost ventilation airflow by 275%! High airflow rates are necessary only during night. During the day only 36 m^3/h per person are necessary. An opening of 40 by 140 cm height may provide 75m^3/h at a $\Delta T = 5°C$ and 47m^3/h at $\Delta T = 2°C$. These dimensioning calculations leaded us to divide the high vent in two parts and to make it open right or tilted. The user instructions are simple and easy to understand: "tilt the top vent during working hours winter or summer. During winter, you close it when leave the office and during summer, you open completely one or both vents, according to your cooling needs; you put it back to the tilted position in the morning."

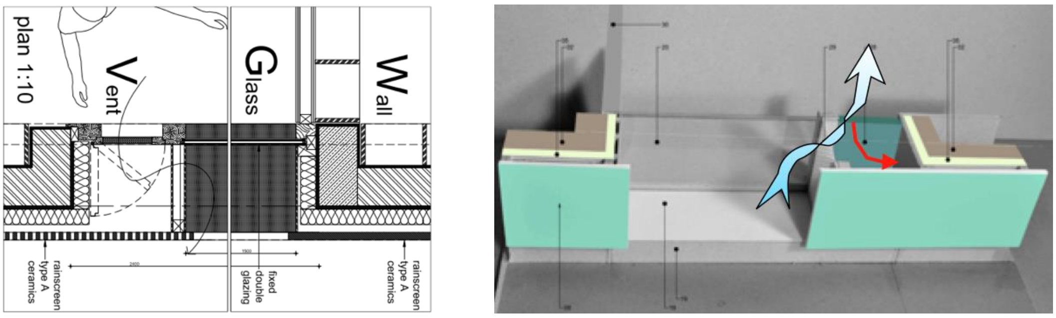


Figure 14. South façade vent. Air enters from the side of the glazing through a perforated protection sheet metal protection.

As we can see from the photos of the following figure, lighting openings are dissociated from air vents. This makes it possible to correctly treat the glazed part, hiding frames or any obstacles and divide, protect or hide the vent part. In the south façade, air comes from the side of the glazed opening, after passing through a perforated sheet metal. On the North, light and façade air comes directly after the protection.

Figure 15. Tilted north façade vent, north façade open right, south window from outside, south vent from inside.

As we can see on the second picture above, all offices are equipped with a ceiling fan. This offers the ability to the users not to use air conditioning up to 28-29°C of internal temperature and use the roof fan instead, drastically reducing the hours of use of air conditioning. It also prohibits wrong use of the window, completely open when external temperature is around 30°C and users like wind breeze. If the user wishes an air movement, he or she may use the ceiling fan, avoiding excessive heat and dust entering in the office.

2.2.7 Technical installations

The building is heated and cooled by VRV technology. High performance VRV are installed on the top of the building 2 and 5 and refrigeration gas is circulating in the buildings to deliver heating or cooling through a fan coil unit in offices. With the ceiling fan this is the only mechanical installation for heating, cooling, and ventilation. On the figure below we see all technical installations for building 5 (618 m2 of heated / cooled area): 4 VRV's of 4.5/4.7 kW thermal power each (30 W/m^2), a solar collector for hot water production, a water storage tank, and a chimney for natural ventilation.

Figure 16. Bioclimatic design at to end is translated to technical sobriety, here all the technical installations of 618 m^2 building.

3 Monitoring plan

The objective of the monitoring plan is to understand the real building dynamic operation, analyse the real energy consumption, indoor comfort, and indoor air quality.

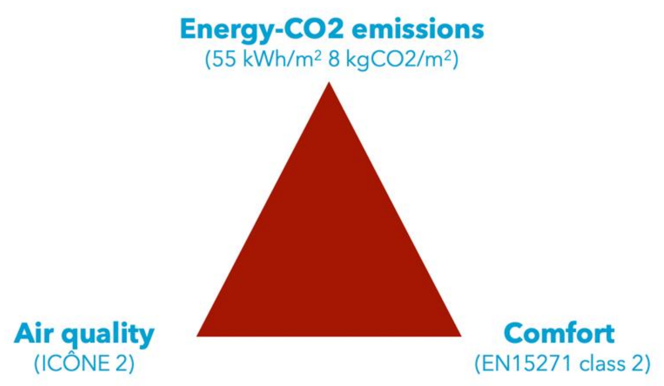


Figure 17. The E-DYCE monitoring tryptic: energy and CO2 emissions, air quality and comfort.

With the energy consumption analysis, we would like to compare the real ~~the~~ EPC expected theoretical consumption and validate the D-EPC prediction according to adapted and real conditions.

Thermal comfort evaluation in a passive building is of capital importance. Energy savings should not be translated to user discomfort. Especially in a passive bioclimatic building, the dynamic behaviour of the building is much more depended by users' actions (opening windows, switching on and of air conditioning and ceiling fans, using solar protection). Comfort during real free running hours of the building must be verified.

Air quality with natural ventilation is of equal capital importance. Sometimes, ignorant "experts" or mechanical ventilation lobbies accuse natural ventilation of poor air quality or designate it as the origin of thermal discomfort based on arbitrary perceptions. This debate has already risen during building design and the real performance of the building must be demonstrated in final phase with real results and not with opinions or perceptions. This is a topical debate this days, as the ministry of education plans to install mechanical ventilation to all naturally ventilated schools, without pre-evaluating their real indoor air quality.

3.1.1 Monitoring equipment

For this demonstration case E-DYCE project wished to test the effectiveness and validly of low-cost commercial comfort and indoor air sensors. We used Netatmo sensors, giving the possibility to measure temperature, humidity, CO2 for the internal conditions; temperature, humidity and wind speed and direction for the outside conditions. The cost of such an equipment (similar products exist in the market) is 160-250 € per station, with 60-70 € for every additional room and ~100€ for the anemometer. This brings a complete station for 4 rooms maximum, and external meteorological conditions including wind measures to ~ 500€. For the energy measurements we relied on existing sub-meters that we connected to the cloud.

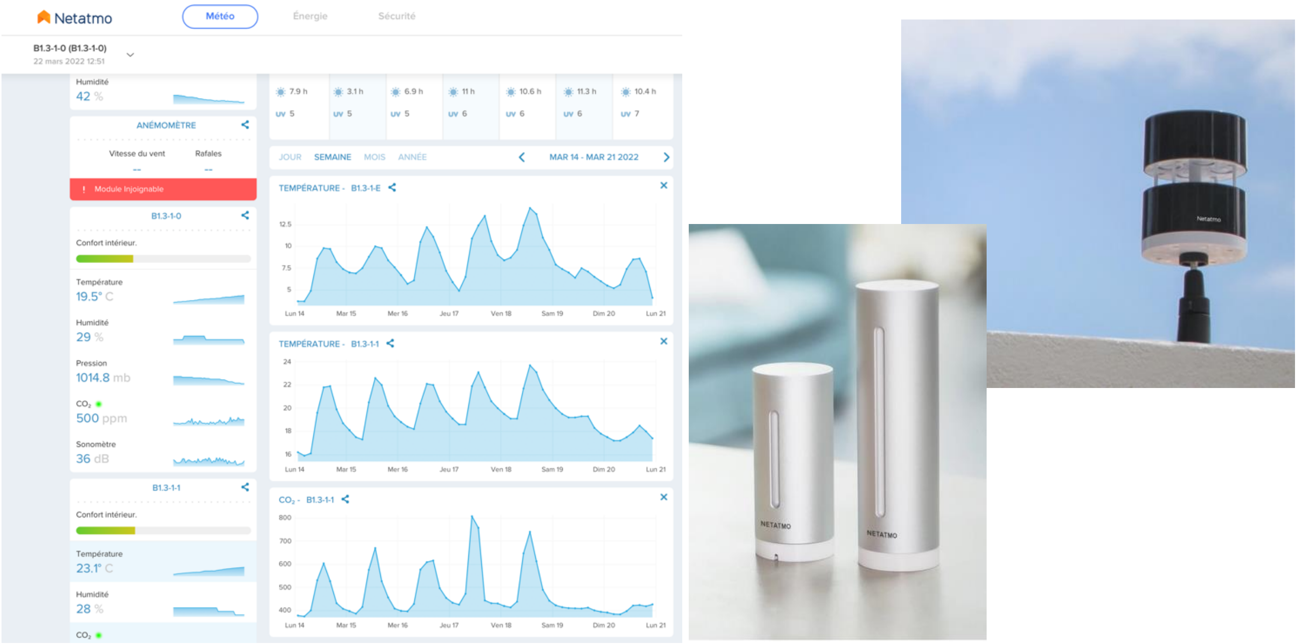


Figure 18. Commercial "general public" indoor and outdoor monitoring of buildings.

3.1.2 Zoning and positioning of the monitoring material

As the building behaviour is different for each orientation (this is the typical behaviour of passive buildings) we oriented the monitoring zoning according to the space specificities.

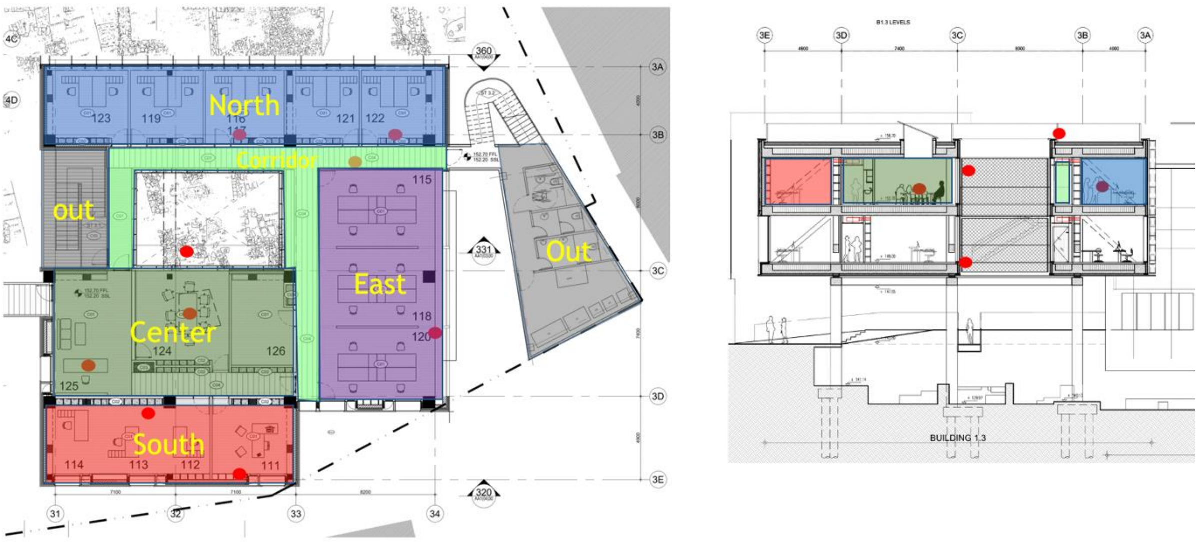


Figure 22: Zoning for indoor environment quality monitoring in Building 3.

IEQ sensors (temperature, humidity, CO2) are positioned in the best available protected comfort zone, generally on or under an office desk or nearer to an open indoor environment shelf. For this case study, we privileged low-cost commercial sensors (Netatmo) for indoor environment quality and for the local meteo (temperature and wind speed, and direction). For energy consumption, we used the existing network general meter and the submeters per building and use. The use of Netatmo sensors communicating with Wi-Fi from the central sensor to the cloud and with an internal radio signal between the central and peripheral sensors was found challenging. We had to handle communication problems between the central sensor and Wi-Fi not present in all the buildings for security reasons but also between the central and peripheral sensors. We were obliged to renounce some measurements because of the lack of Wi-Fi connection or because of the high distance or obstacles to make communicating a peripheral sensor with the main one. However, the overall selection is satisfactory, and we manage to find good compromises for sensor position. We used some individual professional dataloggers to control the precision behaviour of the commercial sensors and to complete some measurements for very remote premises.

For placing the sensors in the users' offices, we got consent from the employer and the individual users during the personal interview. No direct refusal was registered, which could be caused by the direct relationship established during the interview, but also because of the user's curiosity about the results (the office users are mainly architects).

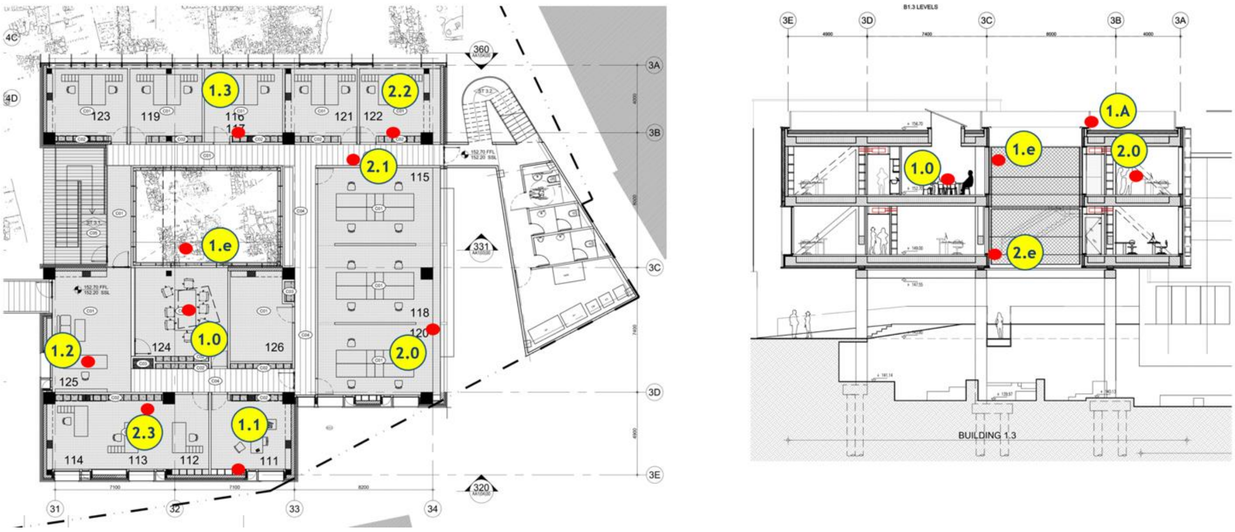


Figure 23: IEQ sensor position.

3.2 Meteorological data

As the installation of a robust meteorological station in the building was not economically feasible, it was decided to retrieve weather data from other sources and use the partial measured meteorological data by Netatmo to confirm the validity of the downloaded from the online available source of [NASA POWER.](#)

4 Visual inspection and interviews with tenants.

We visited and discussed with the occupants of all monitored offices. We applied the clinical method, introduced first by Jean Piaget [1] in cognitive science that consists of a structured guided interview where the subject response is influenced as less as possible by the interviewer. This method in our context leads to a deeper understanding of the user's perceptions and motivations determining their behaviour influencing their climatic conditions. For example, we do not ask the users to which degree they are happy of their temperature in summer, but which is the ideal temperature for them in summer and in a free discussion we lead them to tell us where they read this temperature. This is the way we understood that in winter some people say they are happy with 25-27°C and they read this on the air-conditioning thermostat. They are very happy of their environment where we measure 19°C in the morning and 21-22 when they leave the office. The method was called "clinical method" by Jean Piaget because it is like psychiatric interview, with a structured and rigorous protocol.

From the free "clinical discussions" we firstly understood that in general the users are very happy from their indoor climatic conditions, their freedom to determine their comfort conditions, open or close the window, and generally the working environment. This was not the case in the initial questionary of the designers from the previous municipal buildings.

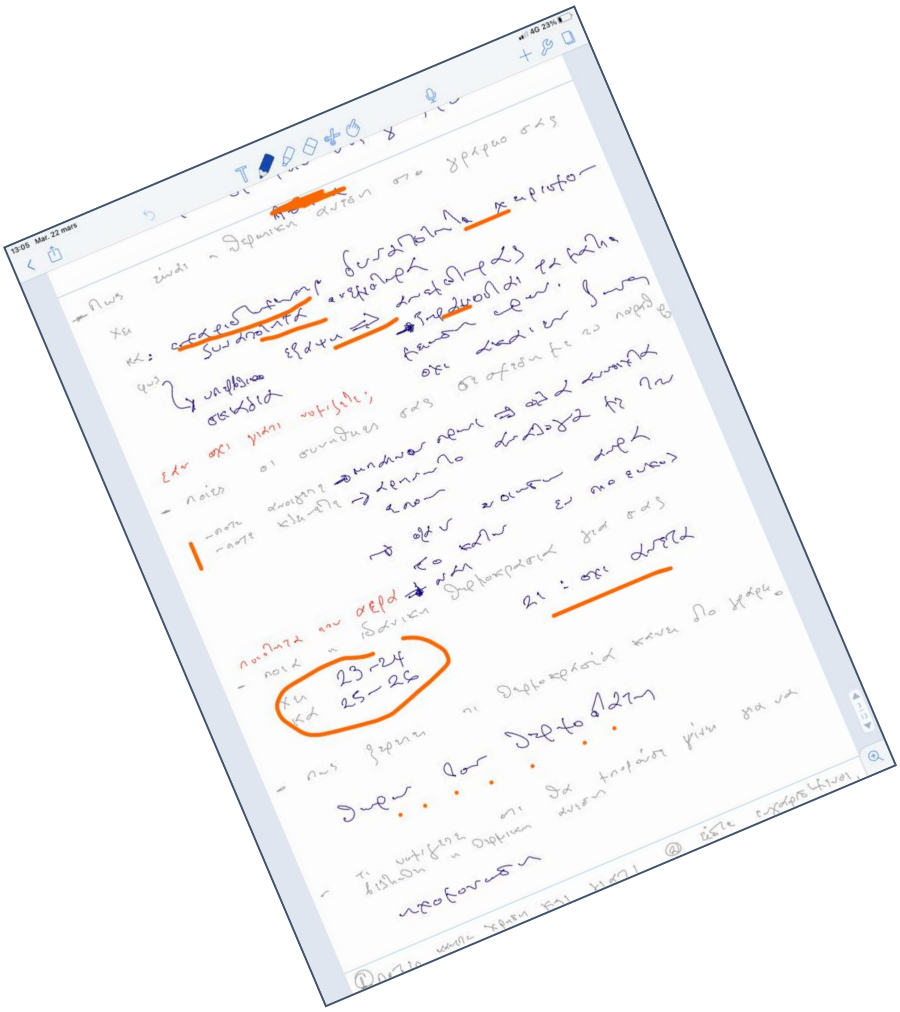


Figure 19. Example of the notes during a "clinical interview" of a user

We structured the discussion in the following theme:

- How is the thermal comfort in your working environment (winter, summer, mid-season). If there are any reported problems, we asked to the users to try to give us their explanation and to tell us if they have a suggestion to make the comfort conditions better.

- What is your everyday practice with the windows? Here in the free discussion, we tried to understand when and why they open and close the windows depending for the different seasons. We ask them also to tell us their opinion about the air quality in their office.

- What is the ideal comfort temperature in the office in summer and winter? If they have an opinion, we ask them to tell us how they know generally what the interior temperature is.

- When do you make use, why and are you happy of
    - Air conditioning
    - Ceiling fan
    - Light
    - Window
    - Solar shading

- What is your opinion on the office energy premisses function and design (air conditioning, ceiling fan, window, solar shading), the use of outside stairs, energy savings.

- We end the discussion asking a general satisfaction rate between 1 (poor) and 5 (excellent).

The discussion takes 15 – 20 minutes, sometimes if there are 2 people in the office, we did the interview simultaneously and marked the differences in the perception if there are any. Users were very friendly and interested about the physics of their environment and have generally strong opinions for subjects like windows, solar shading, or the use of lights, however they are curious for subjects they know less like the air-conditioning functioning.

4.1 Results of the clinical interviews

The names are fictitious. For each topic there is a synthesis of the free discussions provided the perceptions are concordant. If there are divergent views, preferences, perceptions, or level of satisfaction they are noticed.

It is important to know that general views and perceptions are concordant. However, the fact that there is one office out of 11 with some glare and winter discomfort and we mansion every time the positive and negative opinions there is a complaints risk to appear overweighted. 10 people working in 6 different offices of all orientations participated in the detailed interviews. 6 people were interviewed roughly expressing general satisfaction without any problem to report.

4.1.1 Thermal comfort satisfaction and problems

There is unanimous satisfaction for summer thermal conditions and except from the angle office where some discomfort in winter is evident, there was general satisfaction also for winter thermal conditions. However, discomfort complains about the problematic office were strong for winter. Emily explains that in cold days of winter, generally during the morning discomfort is unbearable. Her office mate Lydia agrees and adds that she always has cold feet.

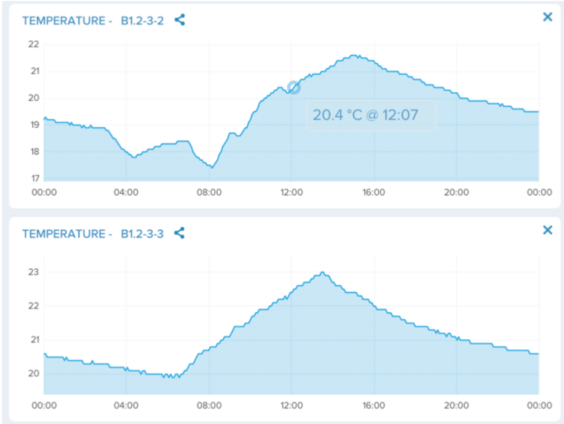


Figure 20. Tuesday 25 January 2022 temperature in the north angle office (top) and a south office (bottom)

The temperature graphs of a single day, Tuesday 25 January 2022, confirm Emily's description. At 8 AM temperature in the office is lower than 18°C while in the south office it is 20°C. At 11 AM, temperature in Emily's and Lydia's office is still 19.9°C while in the south office it is 21.4°C.

Anna reports that although summer comfort is ok, for several weeks during summer solstice there is direct sun entering from the North façade early in the morning. Direct sunlight, although is for 1-working hour, creates also glare.

For lighting, the south and east offices are happy with natural light. These façades are 40% glazed. North façades are 100% glazed without. All the users of the north oriented offices agree that in some cases there is too much light. They do not dispose interior blinds. The glare problem is stronger in the angle north office where sun is reflected from the neighbouring light colour roof.

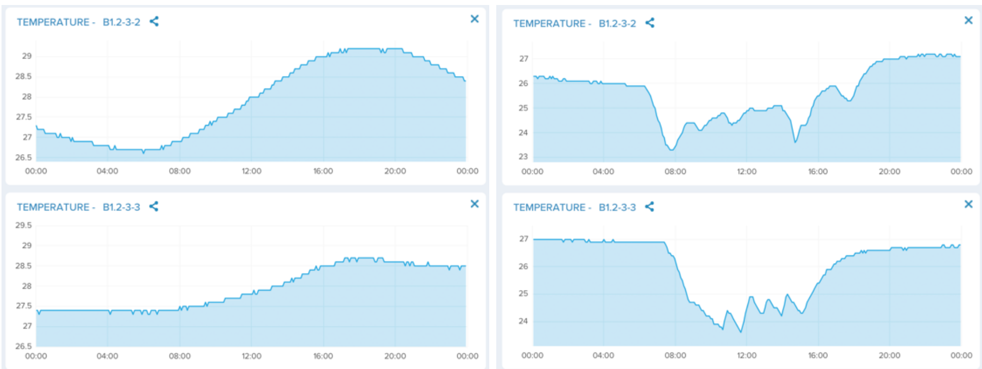


Figure 21. Temperature evolution in a north angle office (top) and in a south office (bottom). On the left Saturday July 2, 2022, with maximum external temperature 43°C and on the left Wednesday June 22 - max 40°C

Users' perception of comfort is concordant with measurements. The only perception which is not visible on temperature graphs is the unanimous morning rise of temperature in the North façade. A hypothesis to explain this perception could be that direct sun is not rising the air temperature but heats up the façade glazing rising the radiative temperature that also rises if direct sun is received by the users without any internal or external solar protection.

4.1.2 Window use and satisfaction

Christina reports: I am very happy with my thermal and natural light environment. As soon as I enter in my office, I fully open the windows, summer and winter and switch on air-conditioning. In winter, when room air becomes too cold, 10-15 minutes after, I put window on tilted position to reduce ventilation. In mid-season I do the same actions without switching on the air conditioning. We switch it on if one of us feels too hot. Sometimes we switch on the ceiling fan instead of the air conditioning.

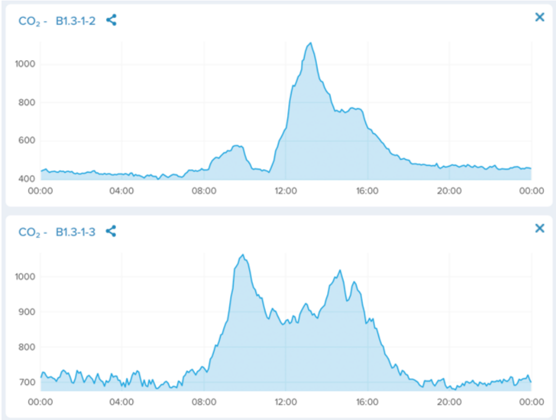


Figure 22. CO2 concentration of a south office with 2 people working in (top graph) and Christina's and Myria's office (bottom graph) one working winter day

To the question when you close the windows, Myria sharing the same office with Christina, reports that they do that when they leave the office in winter. In summer, the building security is closing all the windows after office hours, and they cannot cool the office with night ventilation. Anna has the same habits regarding the windows. She opens it completely every day and she is closing it or tilting it according to the season. Stelios says he opens when it is necessary: all day in summer, tilted when it is too hot, too dusty, or too windy, completely otherwise. He is opening 10-15 minutes in winter in the morning and repeats this at noon.

We could summarise the discussions with all the users as following: we open the window as soon as we enter the office. In winter and in summer, after the morning air refreshing, we reduce the window opening keeping it tiled. We close it if there is too much noise, wind, dust, heat or cold. When the air-conditioning is on, the window is tilted or closed.

All the users are very happy with air quality. This satisfaction is confirmed with the CO2 measurements. CO2 concentration oscillating around 800 and 1000 ppm show that natural ventilation is modulating according to the needs and there is no over-ventilation when heating or cooling is functioning.

4.1.3 Thermal comfort perception and proposals for improvements

Ideal room temperature winter/summer is 25°/26° for Cristina and Myria 23-24°/25-26° for Anna, 24°/23° for Stavros. When Stavros realised that he prefers colder temperature for summer, he adds: I set air conditioning in summer to 25, 24, 23° depending on if I feel hot. Emily considers ideal temperature at 24/25° for winter and for summer. Stavros is provocative saying that he prefers 30°C for winter and 26°C for summer.

After this question, the interviewer asked systematically where they read room temperature. After an instance of embarrassment, most of the people said that they read it or the air conditioning set point. Two people remained with the embarrassment, and they said that in reality they do not know.

Temperature measurements show that the air temperature in the offices is 21±2°C in winter during the hours of use, which is very reasonable operational temperature considering that for the rest of the day the building is free running. During winter free running hours temperature falls to 19, 18, 17°C according to the duration of inoccupancy and orientation, and solar gains of the room. In summer real temperature oscillates around 26°C±1°C.

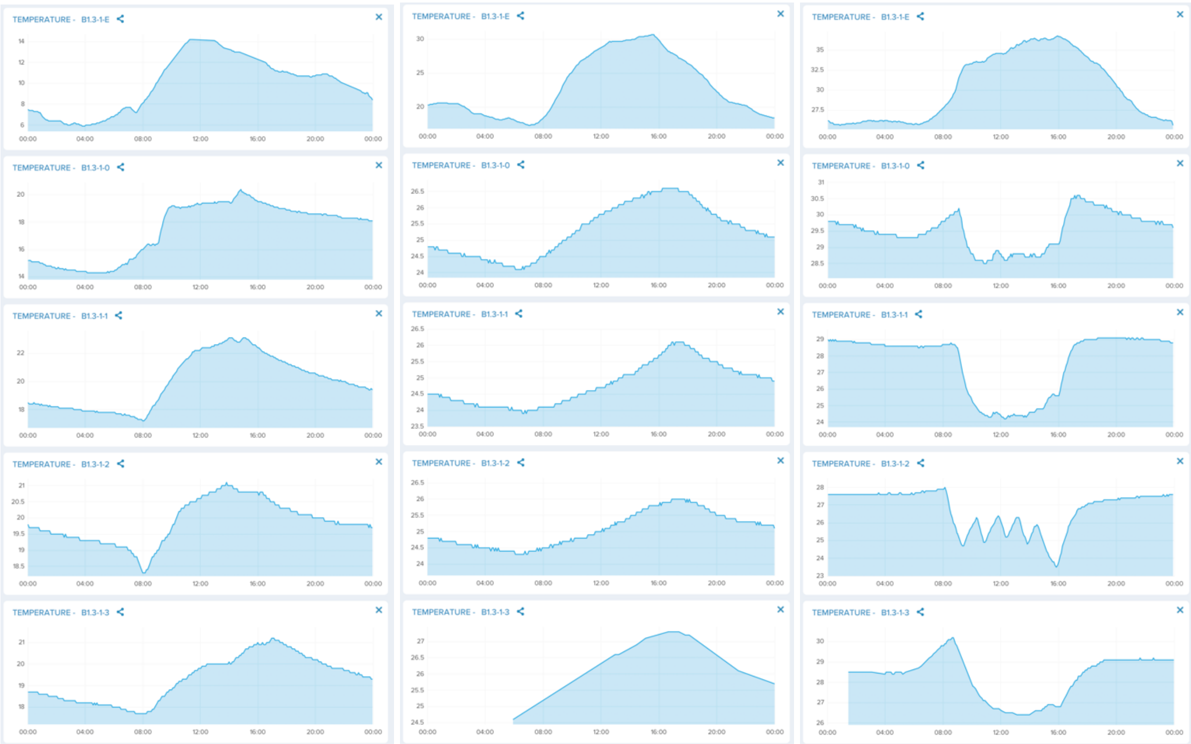


Figure 23. Temperature evolution one working in 5 rooms on 19 Jan, 27 Apr and 25 Jun 2022

Serious divergence between measured temperatures giving ample comfort satisfaction and users optimum perceived temperature indicates that they perceive comfort not in terms of thermometer indications but in terms of physical sensation of well-being. The only arithmomorphic indicator that they dispose is the thermostat setting that they confuse with ambient temperature. May be there is an implicit hypothesis that the air conditioning unit is a perfect machine that provides exactly and immediately the set point temperature. Christina insisted that if the thermostat is set to 22 in winter it is too cold in winter.

The fact that there is strong temperature stratification in winter could be an element of interpretation of this divergence between perception and reality. When the thermostat which is at 1.2 m from the floor is at 22, the floor temperature is at 21 or less creating the perception of “too cold at 22°C”. In the second phase of the project, we could test the possibility to provide thermometers to the users and observe the evolution of their perception.

We have observed that the first use of air conditioning in an office happened in May at 9th of May. However, in the conference room, the occasional users are switching it on starting from mid-April. This is specific and exceptional use of air conditioning is spending a lot of energy, because on VRV is serving 4 to

6 spaces. If a single space demands cooling, even for one hour, the compressor starts and works at very low partial charge. The COP at such conditions of use is low.

4.1.4 Use of energy premisses

Christina never uses ceiling fun because she is complaining that the paper is flying. Anna appreciates its existence because she uses it when she is too hot and need rapid refreshing. She complains that the lowest speed is too high with a result to have dry eyes. However, she uses it in the intermediate season because she realised that the discomfort of dry eyes is less bothering. Stavros rarely uses the ceiling fan because he is bothered by noise and high air velocity even with the minimum speed set. Emily is always using the ceiling fan because she prefers it to the air conditioning in mid-season especially May and October, but she complains that the lowest speed is still too much and there not intermediate position.

Air conditioning is switched on according to the season and the need, especially in the morning. Emily and Lydia do not use at all during mid-season while Stelios (north office) never uses it even in summer. In winter, as its effectiveness is not sufficient to correctly heat the space (one of the problematic offices) he prefers use only the electric heater. Stavros is switching on air conditioning in summer only when there are many people in his office, otherwise he rarely feels the need because he considers his office cool.

Concerning the lights, Christina and Maria are very unsatisfied with the automatic mode. It is fully automatic and they consider that it is always switched on while most of the time they do not need it. When the automatic mode finishes one hour after the end of official working hours, they have to move every 5 minutes in order to re-activate the presence sensor and not be obliged to move to switch it again on. Anna is also unsatisfied for automatic lighting. She complains that she switches them off and suddenly they decide alone to switch again on. Stelios thinks it is a waste to have the lights all the time on.

Figure 24**. Lights on after working hours with nobody in the building, in both offices and corridors.**

After discussion with the users, we extended the building inspection after the working hours of use and we realised that effectively in some offices the lights are on and even in the corridors with the direct sun in the space they were on. According to the building energy specifications they were supposed to be manual on, automatic off. They seem to be fully automatic according to some time schedule.

4.1.5 Satisfaction from energy premisses design

Large windows are generally appreciated. Emily appreciates the flexibility in the opening positions, lower and higher window, opening direct or tilted. The double window is also appreciated by Christina, Anna, Stelios. Christina regrets that there is a protection mesh in front of the opening obstructing a clear outside view.

Air conditioning unit is neutral with no special remarks except than Stelios considering that is too small and useless and Emily bothered but the high level of noise and the direct cold air coming on her head creating headaches.

The internal fabric solar protection is largely appreciated and used by those who have it (south and east) and some of the people in the north offices who do not dispose one consider that it is necessary to avoid too much light in some periods of the date and avoid glare coming from outside.

For the energy saving measures, there was a unanimous proposal to fix the lighting function so that they are not used when they are not necessary.

4.1.6 General evaluation

At the end of the interview the participants were asked to give an overall evaluation 1 (poor) to 5 (exceptional) of their building in terms of conditions of work. Six people spontaneously gave 5 (exceptional) and one 4 (very good). Qualitative adjectives given were : “comfortable”, “human friendly”, “the best working space of my live”, “very comfortable”, “modern”, “offering well-being”, “aesthetic design”. Two people gave the not 3 (good), because of the serious discomfort conditions they experience in winter. One of the critical views was expressed with the phrase “I am not good” in my office, always under light stress and too cold in winter.

Proposals making the building even better were “more arranged spaces for pleasant breaks and human interaction with colleagues”, “shut down the lights during the day”, “shut down air conditioning when absent from the office”, “more places for relaxing during breaks”, “plants in the corridors and internal yard”, “an additional printer inside the office so that we don’t need to go outside in winter for a single printer page”, “put some sound absorption in the corridor”, “make a miracle for a better sound insulation between offices”.

4.2 Visual inspection of the building

The visual inspection confirmed some of the users’ remarks (like for example the misuse of lighting by the building automatic control but we also identified some other misuses, like the shading absence of control after working hours. All these observations are optimisation potentials.

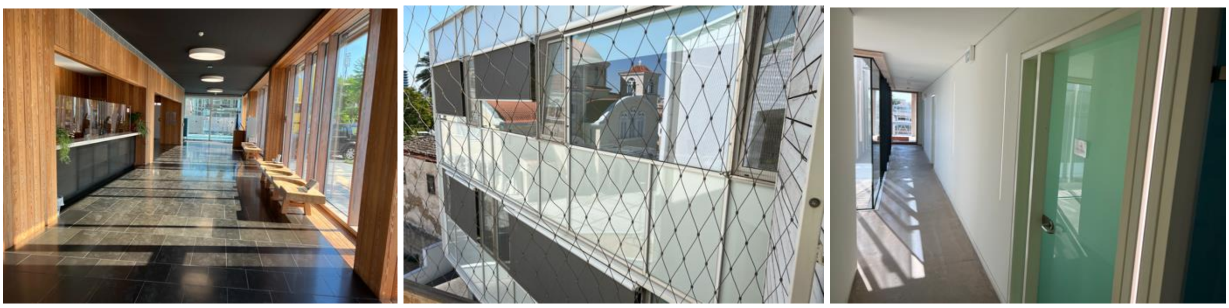


Figure 25. During visual inspection, the inspector realised the lack of solar shading control and lights on all day even outside of working hours.

During inspection we also realised that there were already existing submeters for electricity for the mechanical services (VRV's and fan coil units) separated from the general electricity consumption (lighting and office equipment) for each building. There is also sub-metering for PV production additionally to the general energy consumption of all the buildings.

As there is no heat production and use of fossil fuels, the only energy consumption for all the complexes including all the buildings is the unique electricity meter provided by the Electricity Authority of Cyprus. For the global analysis of all the buildings we may also use the electricity bills (monthly) and disaggregate the total consumption per building and use according to the submetering.

5 Monitoring results and conditions of use.

5.1 Energy and comparison with the static EPC

In this chapter is presented an evaluation of the performance gap of each building compared to the EPC. This comparison is effectuated between the yearly DEPC-operative consumption and the EPC final energy consumption for heating, cooling, and DHW (E_{HWC}). Additionally, an energy signature showing daily mean energy consumption against outdoor mean temperature was utilised to better evaluate the reasons of the performance gap. Finally, data from the DEPC operative consumption were used to identify the operative free-running period of each building.

5.1.1 Real energy consumption of buildings 1, 2, 3 compared to official expected EPC

The Cyprus Electricity authority billing is monthly, and this enables a monthly analysis of energy consumption. As soon as E-DYCE demonstration case analysis started in February 2020 the municipal authorities transmitted the energy bills starting from 2019. Even before analysing the gap between expected and real energy consumption, someone may easily realize the uneven monthly energy consumption and especially during heating or cooling months. This feedback with E-DYCE observations was communicated to the municipal technical service and the maintenance department asked to the maintenance companies to clean the filters and revise the air conditioning operation. Nobody knows what the reason of high energy consumption was really, the fact is that after this revision the regularity of energy consumption is spectacular with significant energy consumption reduction.

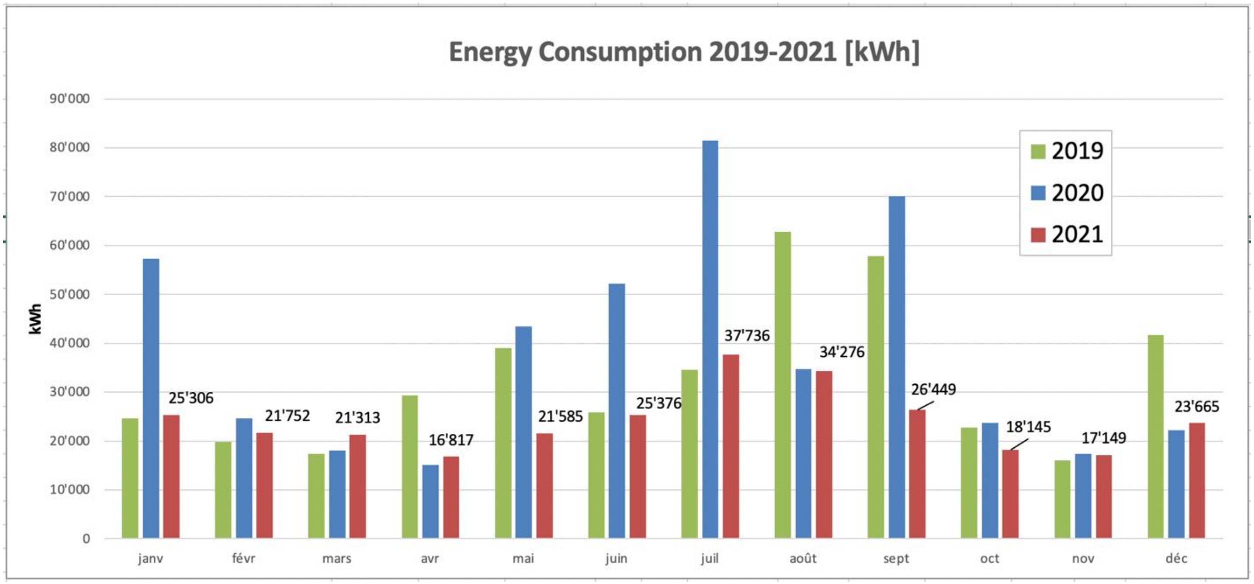


Figure 26. Monthly total electricity consumption for heating cooling, lighting, and office operation according to energy bills.

The first year after commissioning the performance gap was 145%. Next year, 2020 overconsumption raised to 170%. Covid situation might have contributed to this rise because there was a generalised instruction to work with open windows. However, there is no evidence to support this hypothesis with sufficient assurance. After reporting the gap of performance, we observe a significant energy consumption reduction. The performance gap from the EPC calculation is 7% (289.589 kWh instead of 270.260 kWh) and 1% from class A limit (285.732 kWh). This reduction is without any E-DYCE optimisation proposal. This process will take place after month 24 of the project. We can say that simply observation and questioning energy consumption reduced by 70% performance gap, and we are ready to start building optimisation of a normal building without performance gap. This will show the real power of E-DYCE analysis.

Table 1. Evolution of yearly energy consumption according to bills and comparison with EPC

	KWh	€	cent/kWh	Gap from EPC
EPC	270'660			
Category A limit	285'732			
Energy consumption 2019	391'677	55'378	14.14	145%
Energy consumption 2020	460'439	50'972	11.07	170%
Energy consumption 2021	289'569	59'012	20.38	107%

As we see on the table above, the price of electricity raised from 14.14 ct/kWh in 2019 to 20.38 cent/kWh in 2021. The realized energy cost saving corresponds to 34.825€ (59%). The last energy bill in April 2022 raised to 27 cent/kWh and in late summer they announce prices around 50 ct/kWh.

5.2 *Official EPC of the buildings*

As for all buildings, the designers were obliged to produce an EPC for the construction permit.

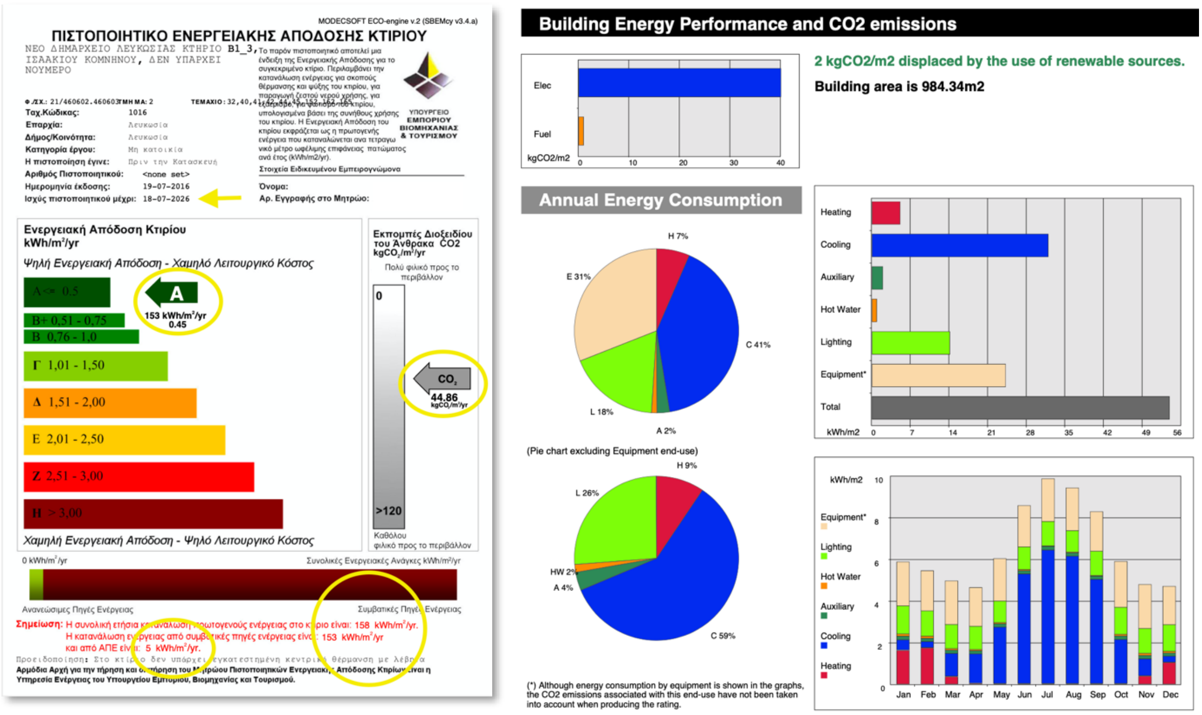


Figure 27. Official EPC for building 3. With yellow we see the quantified information to the owner.

A rapid analysis of the quantified information on the cover page of the certificate for the owner reveals that there no connection between the "EPC" energy consumption and the energy counter. Primary energy, kgCO2, ratio of the EPgl are indicators intelligible by the labelling authority and may be by the energy expert. Even the final energy of the different uses, heating, cooling, hot water, lighting etc. are expressed in specific energy consumption and there is no counter for each one of them. If an owner want to check the real energy consumption it is not possible to do it without performing some calculations. Even simple calculations like translating specific energy consumption into the total energy consumption noted on the bills it is not simple for most owners. Controlling energy consumption compared to the expected one is by default a job of an expert.

In our case, we have a global energy counter for the whole complex of buildings. To make correspond the energy consumption to counter, either the energy consumption of the bills must be expressed into specific energy consumption, eventually weighted with the EPC individual performance of the buildings, or we compare only the global specific energy consumption for all the buildings.

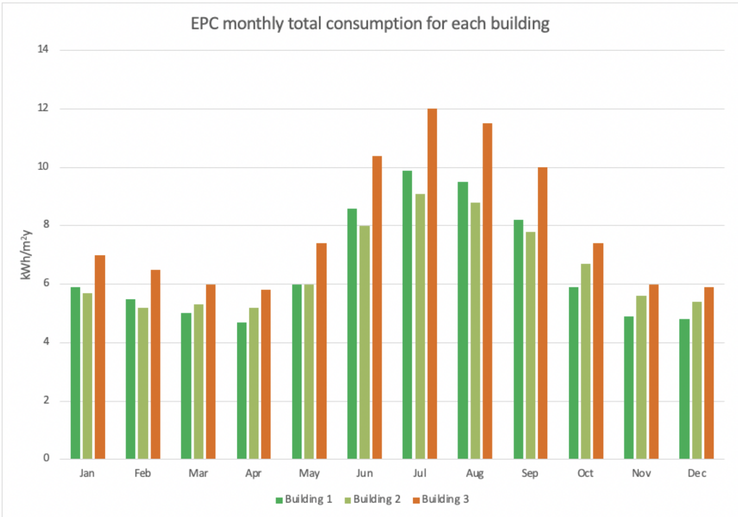


Figure 28. Specific total energy consumption for heating, cooling, ventilation, DHW, lighting and office uses for the 3 buildings. Building 3 consumes more because it has more façade area per heated area.

As we see on the previous graph, building 3 is calculating more in all seasons. Certainly because of the higher envelope surface are per heated area. The internal yard increases significantly heat gains in summer and heat losses. The exposed floor also played a role although it is insulated.

5.2.1 Monthly comparison between EPC and real energy consumption

To do this we evaluated a mean specific energy consumption for the whole complex weighting the specific energy consumption of each building by its surface area.

The graph that follows shows that in January, May, June, July, and September 2020 there was a clear drift of energy consumption, probably because of a technical problem of the air-conditioning system. After the maintenance service of the installations, we see that the energy consumption is regular, following closely the EPC simulated energy consumption. We can see the 7% performance gap distributed mostly in July-August and December, January, February Mars. This gives us a hint for the energy consumption optimisation. Either there is a need of a new maintenance service, if this difference was not because of weather differences provoking higher air conditioning consumption. User actions might also contribute to energy optimisation.

However, even if the total energy consumption monthly profile is fitting closely to the EPC calculation, interpretations should be cautious. From December to March there is a significant energy consumption for heating and for cooling (Figure 29). From the inspections we know that there is never cooling during winter. If for example sun penetrates in the building overheating it, it is so simpler to open a window to get freshness rather than running an air conditioning machine. The constant energy consumption for office equipment and lighting represents 49% according to total energy consumption. This seems however to correspond to reality because in November, where air conditioning is rarely operating, the total measured energy consumption corresponds to that predicted by the EPC (~5 kWh/m^2.month).

When we will have a complete series of energy data on FusiX, it will be possible to analyse the energy consumption of the different processes and target optimisation better.

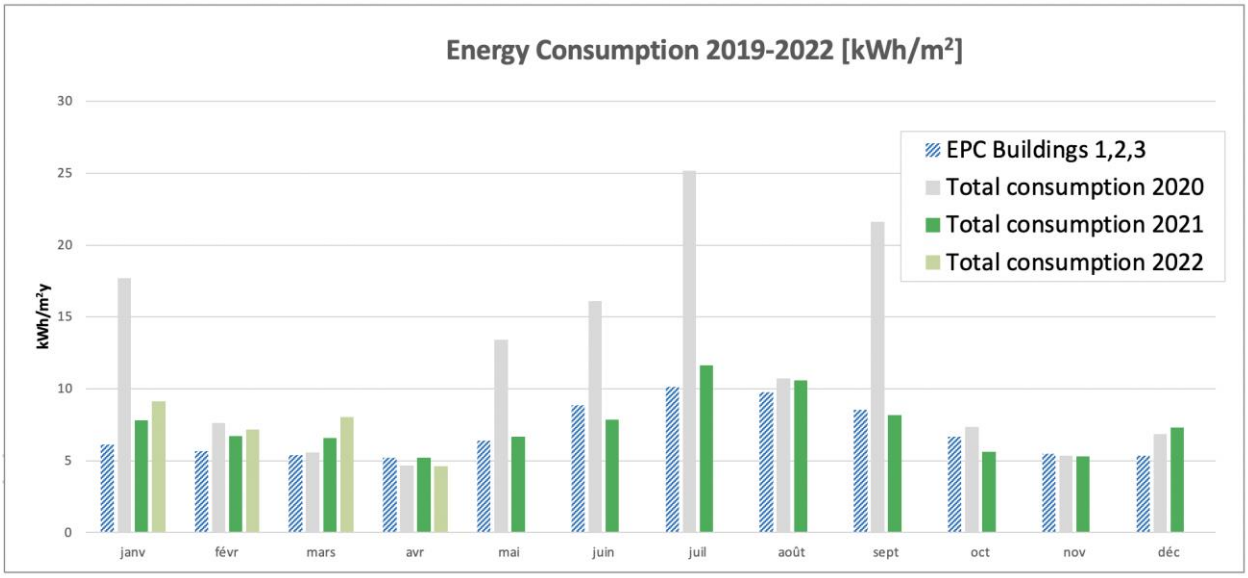


Figure 29. Comparison of expected EPC specific energy consumption with the billed energy consumption.

5.3 Thermal comfort

We measured temperature and humidity in typical offices in building 3 and 2 of all orientations. Although offices behave differently depending on façade orientation, comfort is generally assured in summer, mid-season, and winter. However, one office on the second floor of building 3 and two of first floor are too cold in winter cold days.

5.3.1 North and South thermal behaviour.

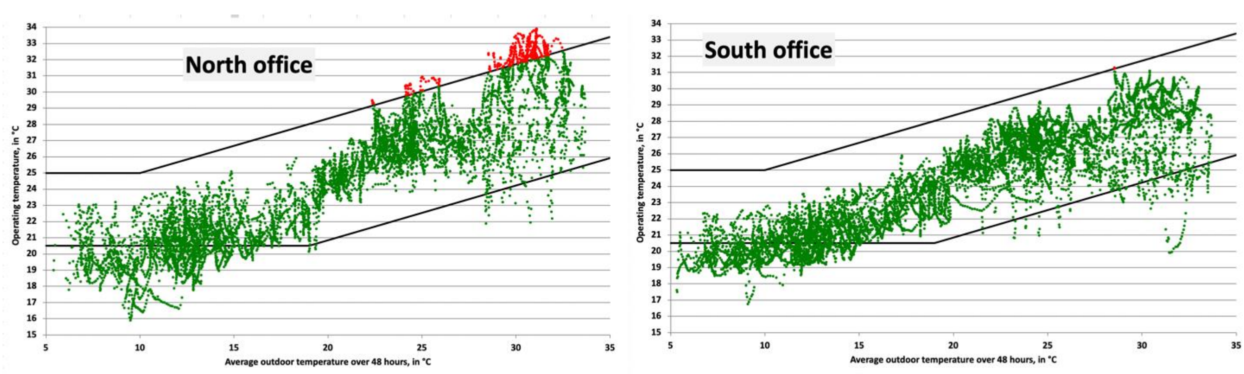
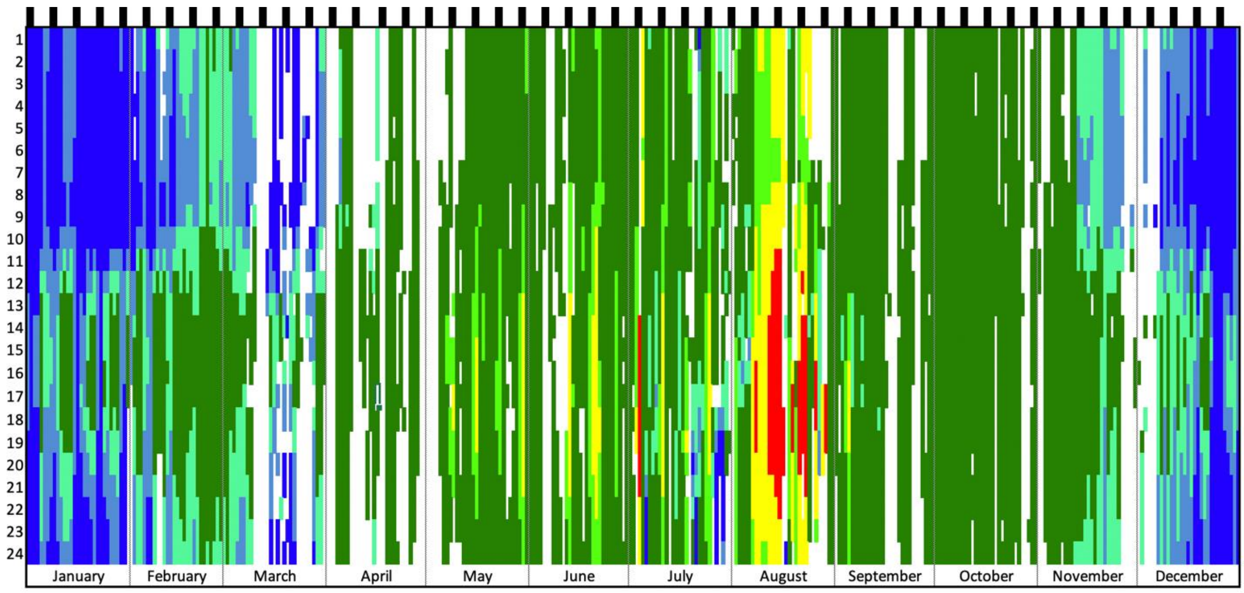


Figure 30. North and South office comfort behaviour

As comfort diagrams show the great majority of points are inside the comfort zone. There are several points in the cold area during winter and hot points in summer. We have 7 overheating points in summer for the south office and 369 for the south one. However, an attentive identification of the dates of these points show that they occur during summer holidays, weekends, and some particular days, may be due to an absence of personnel in the office when air conditioning is off. Cold points occur mainly during Christmas holidays and weekends. Some of the cold points occur during the first working hours in the morning 7 to 9 am.

On the time chart that follows, weekends are noted with black on the top of the chart, the hours of the day on the left of the graph and months on the bottom. We must notice also that the mean of hour 8 for example, includes values between 7:01 to 8:00.

North office



South office

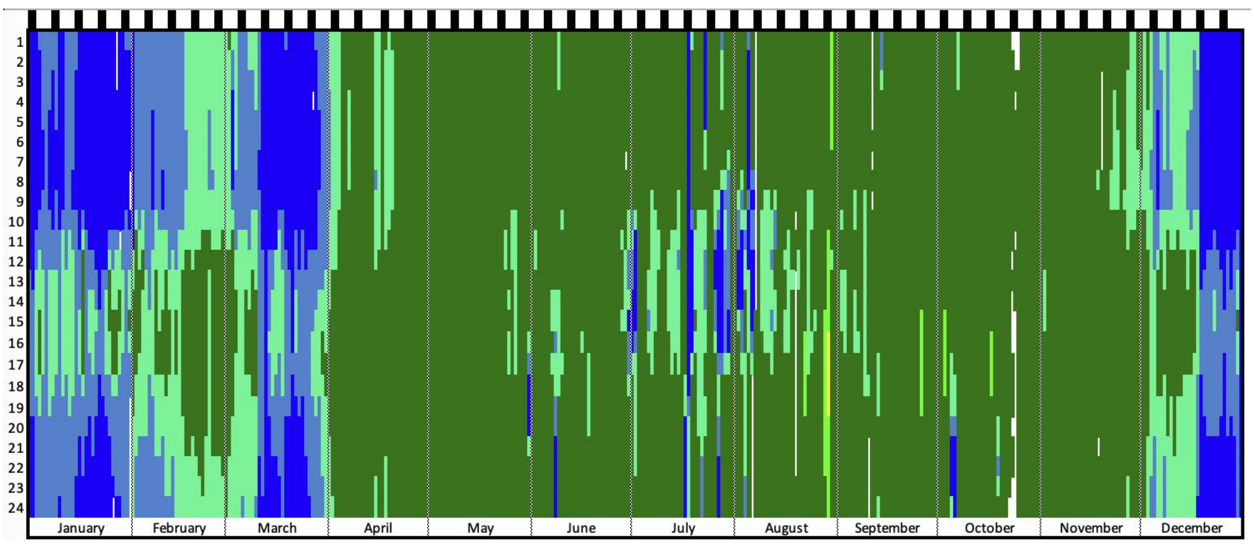


Figure 31. Time chart of typical north office on the top and south office on the South.

Comparison of the behaviour of north and south offices indicates that in general comfort is assured in both orientations, however, there is a net difference of temperature during free running hours. Overheating hours in the north office appear mainly during 3 weeks in August and some days I may and June, probably when air conditioning was off for some reason (absence of the office or public holiday). In the south office during the end of July there are cold points on the graph. On comfort diagram there are some points at 22-23°C when the mean outside temperature is over 30. For both offices in the cold winter weeks there are cold hours during the first hours of the day (8-9 AM). This is because of stratification and the inertia of the office until it heats up. Heat distribution is through a fan coil on the top of the office, on the ceiling. Thermographic analysis shows a significant stratification in winter, with the ceiling air at 23-27°C and the floor at 19°C.

This morning discomfort was not reported by tenants. Perhaps because of psychological reasons. They come cold from outside, they remain well dressed at the first hours, they switch on air conditioning and wating the office to warm up they do not perceive cold. However, when this phenomenon that is identified on the time chart is to intense users are complaining, and this happens on 3 offices north with extra heat losses

5.3.2 3 offices with winter discomfort.

Measured data and thermographic diagnosis in winter confirm users complains about these offices. There was also complain about women WC which is outside the heated area. Although we measured temperatures outside the comfort area in the corridors which are not directly heated or cooled, there was no user complain.

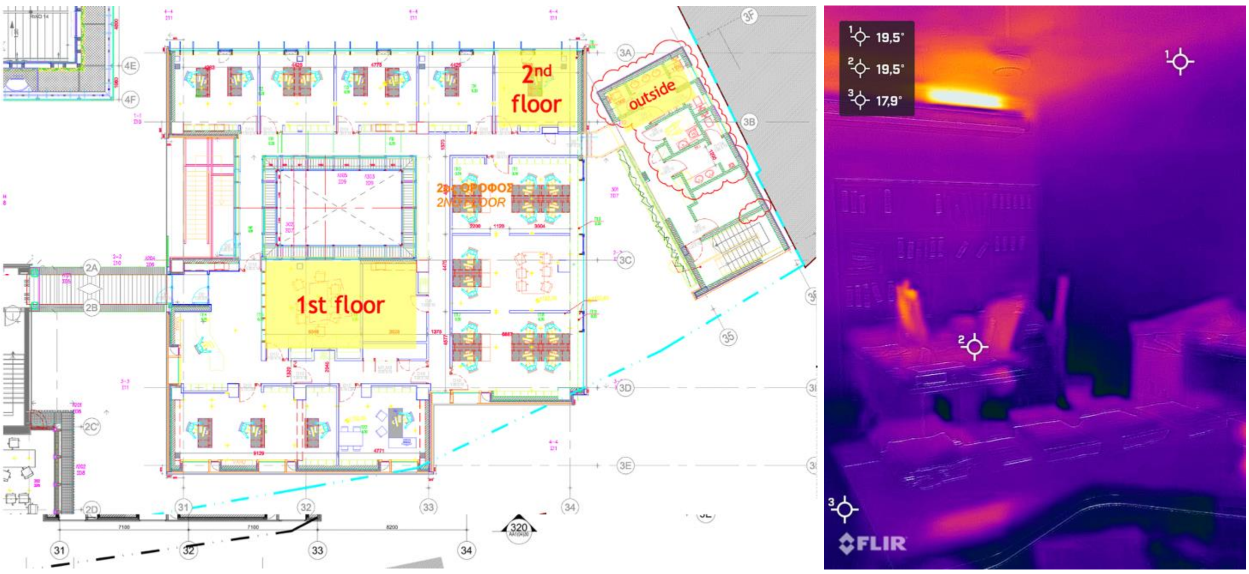
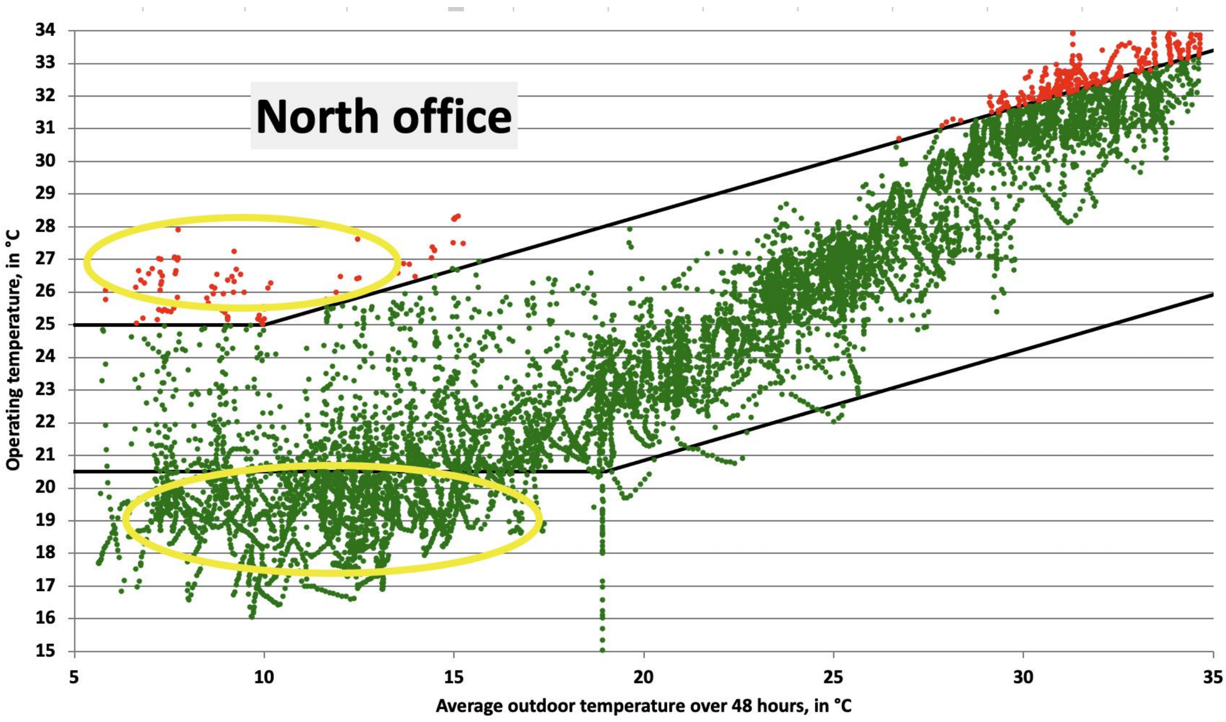


Figure 32. Zones where winter discomfort was reported.

The thermographic picture shows a significant stratification in offices without solar heat gains. This stratification is due to heat distribution mode through air at the ceiling and it is stronger during the morning hours. The office takes 2-3 to warms up until the floor because of the very high thermal mass. As a result of this discomfort, the users of these offices are equipped with individual electric heaters. Discomfort is more intensive expressed as cold feet.

The thermographic analysis shows that the office design with fully glazed north façade combined with the absence of solar gains, in an office with very thermal mass and low power ceiling distribution of heat through air, creates a shower of cold air near the cold glazing. The fall of cold air creates cold draught under the office. This phenomenon appears only in 3 offices with an additional exterior wall of the floor (angle room or rooms with the floor towards outside). The neighbouring offices, which are completely identical but with two lateral internal walls do not complain and the temperature time chart shows that the phenomenon is less intense and shorter in time.



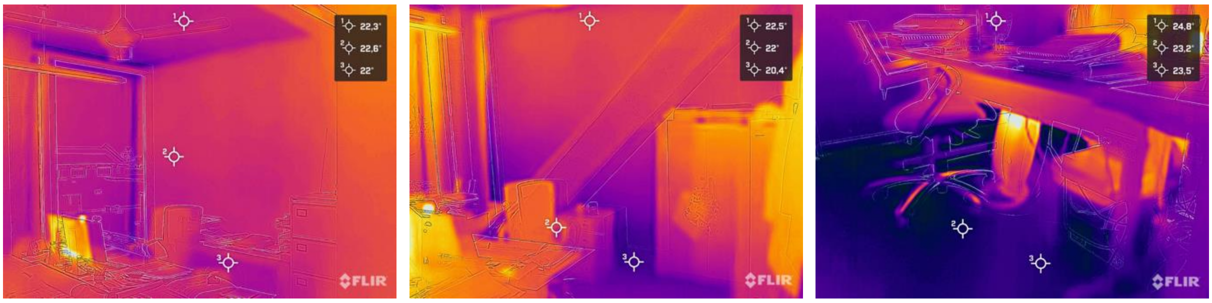


Figure 33. Low temperature stratification in the north interior office (first picture), high stratification in the north exterior office (second picture) and use of individual electric heaters by the users for the cold premisses.

As we see on the thermographic analysis in the offices with lateral walls towards neighbouring office temperature stratification is low and floor temperature is within the comfort zone. In the offices with high heat losses and no solar gains stratification is high (middle picture). The users of these offices (3 in total) are equipped with individual electric heaters compensating discomfort.

On the comfort diagram we may identify temperatures 20-28.5°C during winter in the office with the use of individual heaters, but also a lot of cold hours, which occur mainly when users are absent, but also during the morning hours, creating discomfort.

Several solutions were proposed for these offices: program air conditioning to automatically start 2 hours before office hours, use an internal fabric shading to solve reported glare problems and hide also cold glazing, or change the fan coil unit fins to direct air downwards. These solutions will be tested in the second year of monitoring and their efficiency might be observed on FusiX platform.

5.4 Indoor Air Quality

Similarly to the thermal comfort evaluation, the IAQ evaluation is performed with carpet diagrams. The carpet diagrams are done with CO2 values.

CO2 measurements are shown using the ICONE protocol. This protocol is used in France to evaluate the confinement index in the classrooms in schools. It ranges from 0 to 5 with the following definition [2]:

Valeur brute de l'indice de confinement	Valeur retenue de l'indice de confinement
ICONE < 0,5	**0**
0,5 ≤ ICONE < 1,5	**1**
1,5 ≤ ICONE < 2,5	**2**
2,5 ≤ ICONE < 3,5	**3**
3,5 ≤ ICONE < 4,5	**4**
ICONE ≥ 4,5	**5**

$$ICONE = \left(\frac{2,5}{\log_{10}(2)}\right)\log_{10}(1 + f_1 + 3f_2)$$

f_1 : *proportion de valeurs comprises entre 1000 et 1700 ppm* $\left(f_1 = \frac{n_1}{n_0 + n_1 + n_2}\right)$

f_2 : *proportion de valeurs supérieures à 1700 ppm* $\left(f_2 = \frac{n_2}{n_0 + n_1 + n_2}\right)$

Figure 34 ICONE index definition from [2]

With n_0 being the number of datapoints with value ≤ 1000 ppm, n_1 number of datapoints with 1000 ppm < value ≤ 1700 ppm and n_2 number of datapoints with value > 1700 ppm.

The time chart shows that air quality is excellent all over the year with confinement index equal to zero. These results are of high importance. They show that good window design guides the users to a correct window use for this climate. They correctly modulate the window degree of opening to get the best air quality without killing the building energy performance or creating discomfort problems.

All the offices show similar results as the one shown in the following graphs.

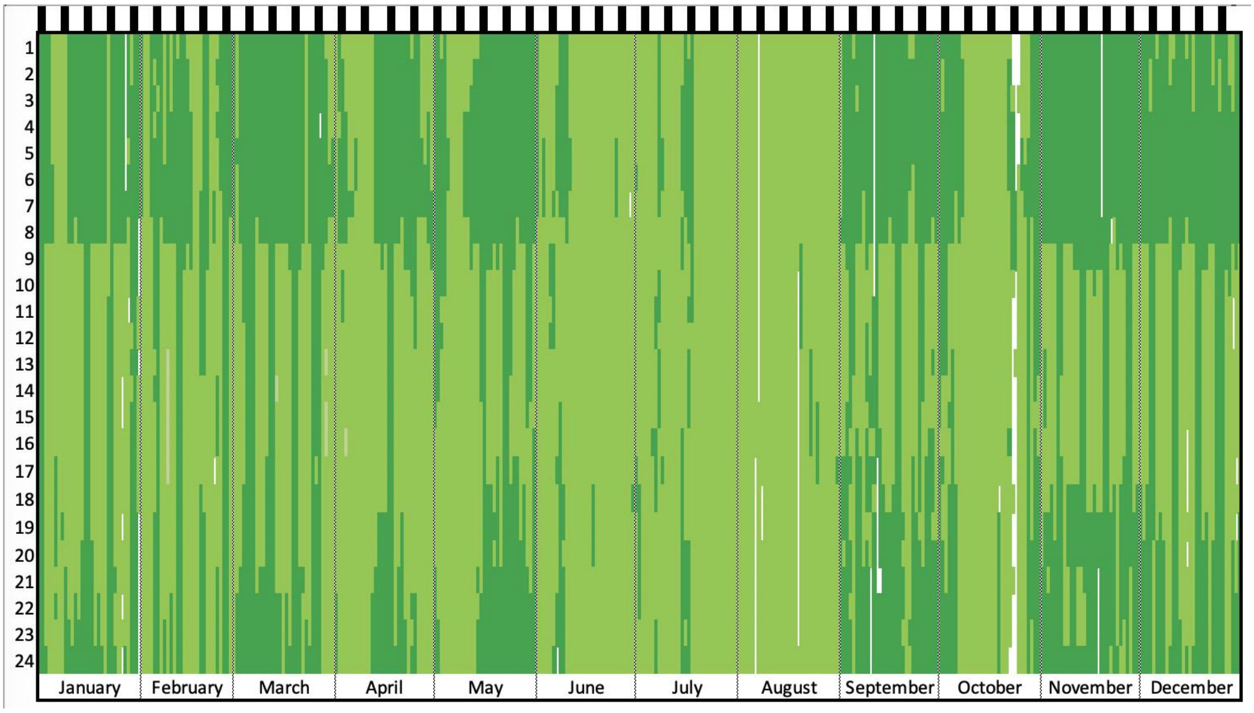
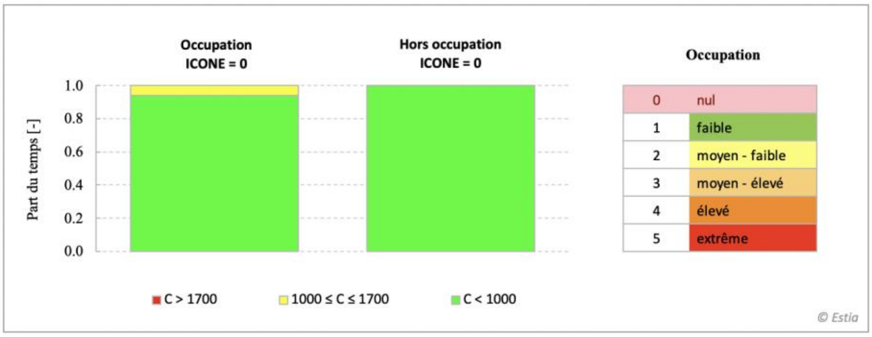


Figure 35. CO2 time chart showing excellent indoor air quality with confinement index equal to 0.



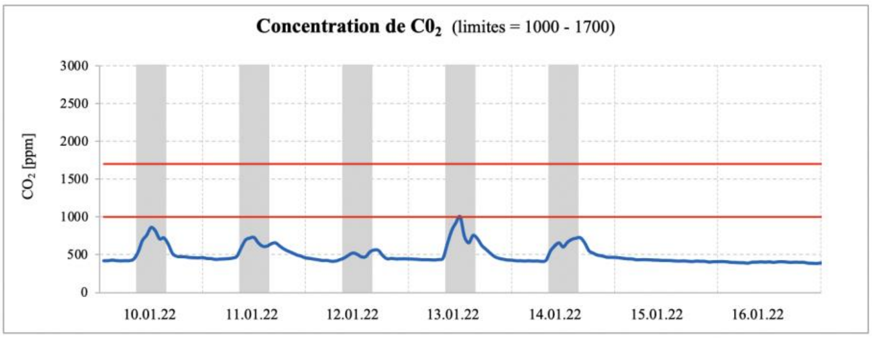


Figure 36. CO2 concentration and confinement index 0

6 Modelling

6.1 Models' development

The models for the dynamic building energy simulations were developed using the DesignBuilder software. This software provides tools facilitating the creation of the model's geometry and permits exporting the model in IDF format for inputting into EnergyPlus, the software utilized in the PREDYCE tool.

For all models, the HVAC systems were modelled using the simplified EnergyPlus ideal load system, which allows the definition of the thermostats' setpoints and gives the net-envelope energy demand for heating or cooling as output. Using these ideal energy demands, building, a good estimation of the final energy consumption can be obtained by adding the coefficient of performance of the building's HVAC system. The outdoor air ventilation was equally introduced using the simplified modelling option as the calculation would be high time-consuming. In all models, the air exchanges were effectuated through three pathways: the infiltration from the envelope's cracks, the ventilation through the buildings' mechanical systems, and the ventilation through the window opening by the occupants.

All models were created using information from the inspection sheet, and the first version of the model corresponded to the standard conditions of use for offices. In the following step, the models were adapted to the actual observed conditions of use, given that the standard conditions do not necessarily reflect the reality for each case. This procedure is crucial for the E-DYCE methodology and is described in the deliverable D2.4. The modified parameters were mainly the outdoor air ventilation and infiltration rates, the solar shading, as well as the thermostat setpoint temperatures.

At this stage, the building models' zoning was detailed and done on the office level. So, each office constituted a separate zone. In addition, the staircases, basements, and other non-heated spaces formed distinct zones. This approach permitted a more detailed interpretation of the results, for example identifying the critical zones. But this zoning approach also led to high time-consuming simulations. In a later stage, all models will be simplified in parallel with the T3.5 in order to better identify how the simplification of models can be done in real cases.

6.1.1 Building 3 dynamic simulation.

The model was created using information from the architectural plans and the inspection protocol available for this building.

The building is constituted of two floors. As each typical floor, contained several offices, the number of heated thermal zones of each floor was equal to the number of offices, plus the corridors. The simulation time for this model was between 10 and 15 minutes, which may not be optimal for running multiple simulations and adapting the model. Thus, it is predicted to effectuate a simplification of the model to reduce the complexity and the simulation time. Figure 37 and Figure 38 present the geometry of the model.

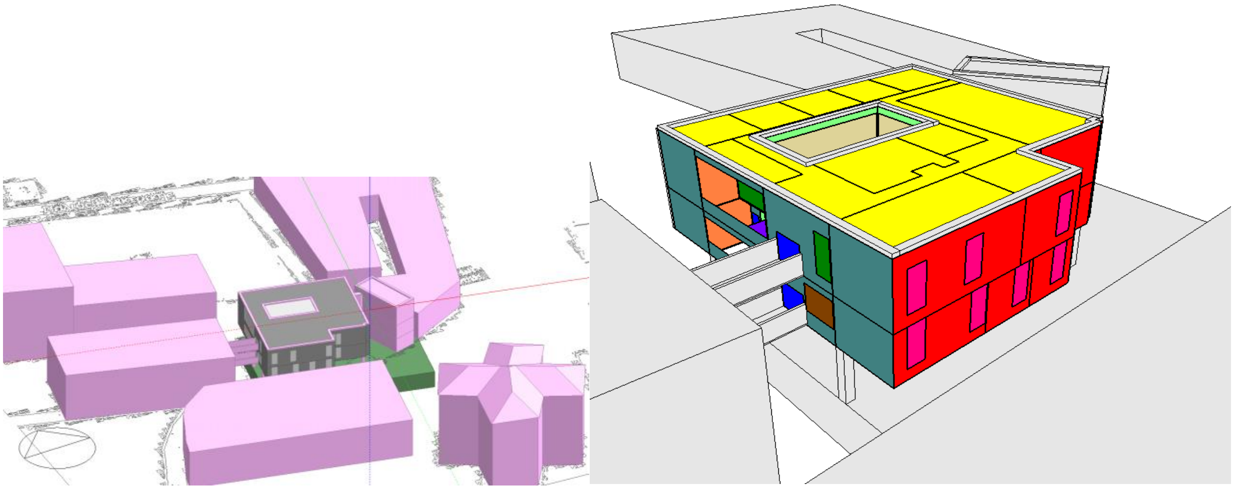


Figure 37: External views of the building presenting the external geometry of the investigated and neighbouring buildings.

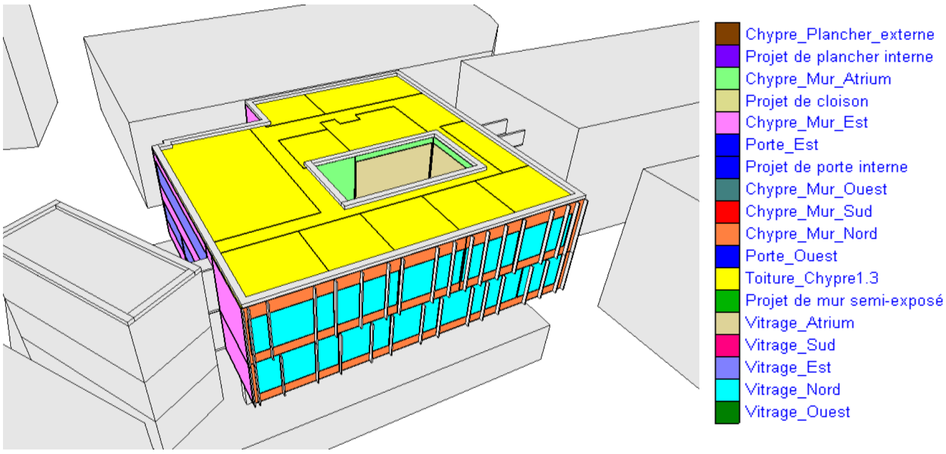


Figure 38. View of the model's thermal zones for a typical floor of B1.1.

6.1.2 Model adaptation

Initially, the model was built using the standard conditions of use, as demanded by the Swiss standard SIA 2024 (SIA, 2015) for offices using standard weather data for Nicosia. However, as the standard values were different from the actual, the model must be adapted accordingly. As users behaviour changes dramatically according to façade orientation, further analysis is necessary to generalise and model it. This difficulty will be treated in WP 3.5 in the next project steps. For the moment, the model was adapted only according to real weather conditions.

6.2 PREDYCE connection and transfer to FUSIX

All models were developed in EnergyPlus V8.9 in order to be compatible with the PREDYCE tool and to be eventually connected to FUSIX. This will be effectuated in a later stage, as the automatic connection via API of the monitored data with FUSIX was not totally available until this moment due to various issues related to the suppliers of the sensing material.

6.3 Comparison of the static and dynamic EPC

This chapter attempted to compare the preliminary results from the different EPC evaluation schemes to identify the added value of the E-DYCE methodology. In the four following sub-chapters are presented the energy signatures obtained from the four different EPC (EPC static, DEPC-AS, DEPC-AA, DEPC-O), as the energy signature is an efficient representation method that can aid in the interpretation of the results. It should be noted that, at his point, the interpretation of the results is limited as there is still some information missing from the case studies, or the simulation models are not 100% adapted to the actual conditions of use. Thus, the results presented are still in a preliminary phase, and the final conclusions may differ.

The preliminary results show method stability. However, these results are obtained with many assumptions both on the consumption side (to disaggregate the total energy consumption and isolate energy consumption of building 3) and on the simulation side (difficulty to model user behaviour).

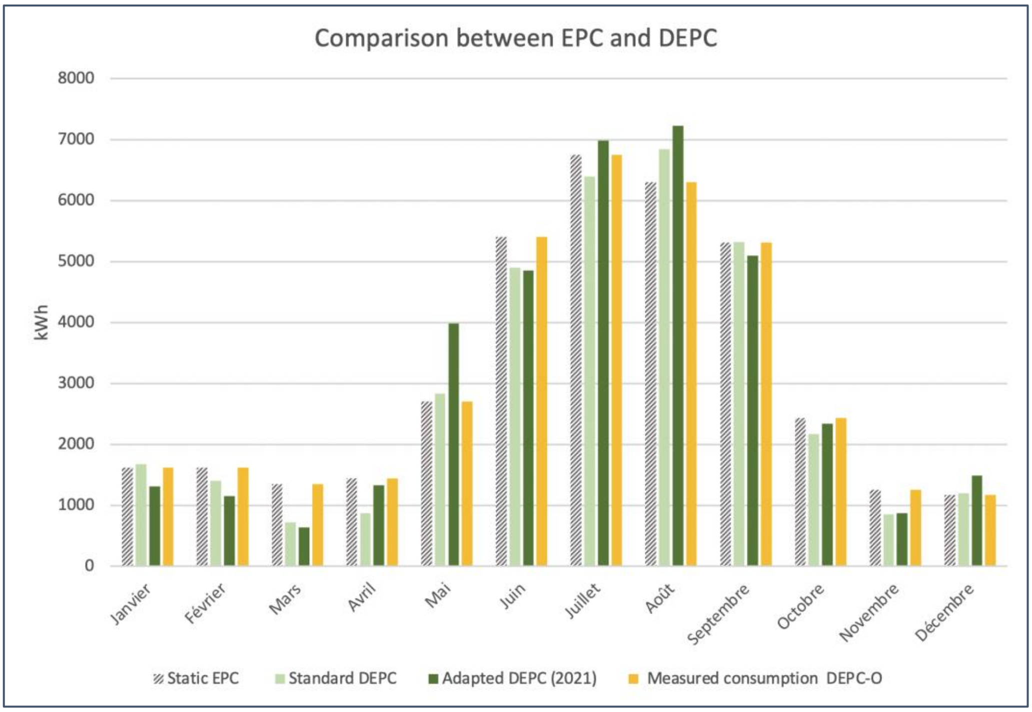


Figure 39. Comparison of EHC between EPC, Standard DEPC, DEPC-2021 and DEPC-0 (measured consumption)

Safe conclusions will be obtained when FusiX will collect a bigger set of energy consumption desegregated data from the submeters, so that we better account only heating and cooling data and the PREDYCE system will enable analyst to perform effectively and rapidly sensibility analysis to analyse different options of user behaviour models.

We know that the EPC static includes cooling in winter when there is never any cooling, but the real and simulated consumption still corresponds. We observe that in May and August adapted DEPC consider higher cooling loads considering hotter weather and the real energy consumption correspond better to non-adapted DEPC. Are the local weather data really hotter in the cite centre? Is the better fitting because of Auguste holidays? Automatised analysis in E-DYCE toolbox will make possible an efficient elucidation of this kind of questions and give feedback to work package 3.5 improving simulation methodology.

7 Conclusion and further steps

Cyprus case study was selected by E-DYCE for two reasons. One was to cover all European climatic conditions and the other to apply and demonstrate E-DYCE developments on a strongly passive and mostly free running building. Furthermore, for this case study low-cost commercial probes for general public were tested.

E-DYCE inspection protocol has been very informative to understand the real function of passive technics. The clinical interview method used to interact with the users also gave a lot of information about their perceptions and their motivations to act or react on building technical or architectural components.

Although the building operation generates a very dynamic thermal behaviour, in general there is a good matching with simulation results. This is promising for the second phase of the project where we will use the collected data to adapt the simulation D-EPC framework to analyse the real performance of the passive technics identified on the building.

We would like to evaluate the potential energy savings of applying strictly the night ventilation strategy. We would also like to be able to predict the comfort improvements with better settings of the heating system in offices presenting winter comfort deficit. Machine operation can be optimised by switching them off in the free running period in mid-season. We realised for example that a 12 kW cooling machine is switched on 4 times in April just to cool a conference room. If other solutions can be found, the real free running period of the building could be extended by one month. We would like not only to realise this energy saving on the demo case but to be able to correctly predict it using the D-EPC indicators describing the free running.

Another objective for the use of the achieved experimental and simulation framework is to question design decisions for passive technics. What is the real effect of ceiling fans. Is it necessary to install so high thermal mass? Thermal mass was very costly in terms of architectural compromises but also in terms of embodied energy. Pre-DYCE framework installed on FusiX, or other simulation infrastructure, and the use of WP3.5 results for simplification provide a nice opportunity to perform sensibility analysis and quantify the real effect of less thermal mass.

The building owner appreciates the results of E-DYCE monitoring that already generated consequent energy savings and wishes to adopt a simplified monitoring and optimisation process tailored to the available human resources and competences. This is very helpful for the project and will help to bring E-DYCE developments near to the user needs.

The passive building in Nicosia proved that passive technics may bring a near zero energy building to a real class A energy performance. This have been already achieved and the building monitoring avoided continuations of an undetected performance gap of 70%. In the second phase we will propose to the municipal technical services a series of optimisation measures and we will control their theoretical efficiency with D-EPC and their real efficiency with the continuous monitoring. These 10 measures are:

- Find acceptable security solutions and apply night cooling.
- Make the monitoring visualisation to the end users and the technical installations
- Optimise lighting with manual on – auto off strategy

- Enlarge the free running period by pre-setting the air conditioning
- Automatise the motors of Est and Ouest blinds
- Rise the temperature of some overcooled spaces
- Complete some incomplete shading
- Fix the comfort problems of insufficiently heated spaces.
- Install the north vertical side fins still pending since building commissioning
- Fix the automatic natural night ventilation there where it exists and it is not operating.

Monitoring and visualising in direct the energy savings with the E-DYCE infrastructure will motivate the technical team to push forward the application of this measures.

8 References

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