Thermal and comfort monitoring guidelines





*20*

Work package: 4

Work package leader: IREC

Responsible partner: IREC

Deliverable 4.2: Thermal and comfort monitoring guidelines

Authors: Jordi Pascual and Lluc Canals Casals

Version: Final

Date: June 2020

IMPORTANT NOTICE: Reproduction of the content or part of the content is authorized upon approval from the authors and provided that the source is acknowledged.

TABLE OF CONTENTS

[PREAMBLE 4](#_Toc46237502)

[1 Obtaining the data 5](#_Toc46237503)

[2 Data analysis and processing 8](#_Toc46237504)

[3 Expected outcomes 9](#_Toc46237505)

[ANNEXES 11](#_Toc46237506)

# PREAMBLE

These guidelines explain the different steps needed to correctly implement the monitoring process to reliably establish the thermal and comfort conditions of end-users’ dwellings, for the ones available, pre and post interventions.

The designed process aims to establish thermal and comfort conditions to:

1. fix the hypotheses needed to adjust possible building simulation models to obtain reliable results,
2. analyze the current status and the impact of the planned interventions, and
3. offer oriented strategies on how they could improve their thermal comfort conditions, which should also impact on health benefits to end-users.

# Obtaining the data

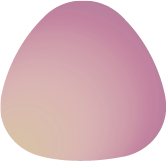
The basis for the expected outcomes is the acquisition of reliable data, regarding the thermal behavior and the comfort conditions, for some representative cases (households) placed in Barcelona area (although other EmpowerMed localities may possibly do the same process).

For this purpose, self-sufficient monitoring devices will be used allowing for, in most of the cases, a do it yourself process. In parallel, just for some few households, and only when possible considering end-users’ predisposition, a more complete equipment will be installed by IREC technicians in order to measure more detailed variables regarding the thermal comfort.

In all cases, short monitoring periods will be proposed that, ideally, will be repeated for the same users over time, in order to both, fixing the status over the different yearly seasons, and capture the variations caused from pre and post interventions.

## Programming and (self)installation of monitoring devices

For the short-periods monitoring purposes, the main equipment used are simple devices able to capture Temperature (T), Relative Humidity (RH) and Dioxide of Carbone (CO2) data (Figure 1), which are expected to be directly installed by the end-users.



|  |  |
| --- | --- |
|  |  |
|  |  |

Figure 1. Different models of self-sufficient monitoring devices (see too Annex 1)

The different devices are plug and play equipment, which means that, once they’re programmed by the IREC technicians, they could be easily installed by the end-users. The equipment has enough precision for the requested information (i.e ±1ºC and 3% HR in normal conditions), doesn’t require for internet connection for the data storage (having data loggers), neither from any electrical connection (they have enough battery capacity to be operative between 3 to 12 months, depending on the time steps of data recovery).

Thus the foreseen process will start with the programming of the monitoring devices from the IREC technicians side, just to calibrate them and to fix the recovery time steps (to 10 minutes). Then, the devices will be ready to be distributed to end-users’ volunteers (1 single device per end-user) during the collective assembly, in which they will be informed on how to “install” the devices; that means, only, in which household places the devices should be located (ideally in the dinning or the living room, as these are the more inhabited rooms, at 1 to 2 meters from the floor, and considering to be a fixed place during the 1 to 2 week scheduled period). The same process will be repeated for the next seasonal or post-interventions periods.

If possible, and by considering the availability of some representative cases, for 1 to 2 households a more complete monitoring set will be installed (Figure 2). This equipment allows monitoring, not only the previously introduced parameters, but also some extra ones regarding specifically to comfort conditions, as the Wind Velocity (WV) or the Operative Temperature (OT).

|  |  |
| --- | --- |
|  |  |

Figure 2. Available comfort equipment

This equipment has more precision than the above-introduced one’s but, on the other side, requires an specialized support from IREC’s technicians. Moreover, these devices take up more space in the households. That means, for this case the process will require for the initial programming (again, regarding the calibration and definition on the time-steps) but, as far as the equipment must be assembled on-site and in household located specific places (also considering the required electricity connection), the installation (and de-installation) is planned to be done by the IREC’s technicians. This means that, during the collective assemblies, the target groups would be informed about this possibility and, if some volunteers exist, they’ll be scheduled the visit for the installation.

It must be mentioned than, for both cases (the basic and the detailed monitoring) the users will be informed about the privacy data rights (Figure 3).

## Devices recovering and data collection

After the installation of devices in households, they’ll be recovered; for the most common cases of the above-introduced, as the ones which are plug and play by the users themselves, the expected return will coincide with the next collective assembly or (if not possible) will be picked up at home by IREC’s personnel. For the other more complex cases, if any, the equipment will be always picked up at home by IREC’s personnel, according to the originally agreed scheduling with the households’ volunteers.

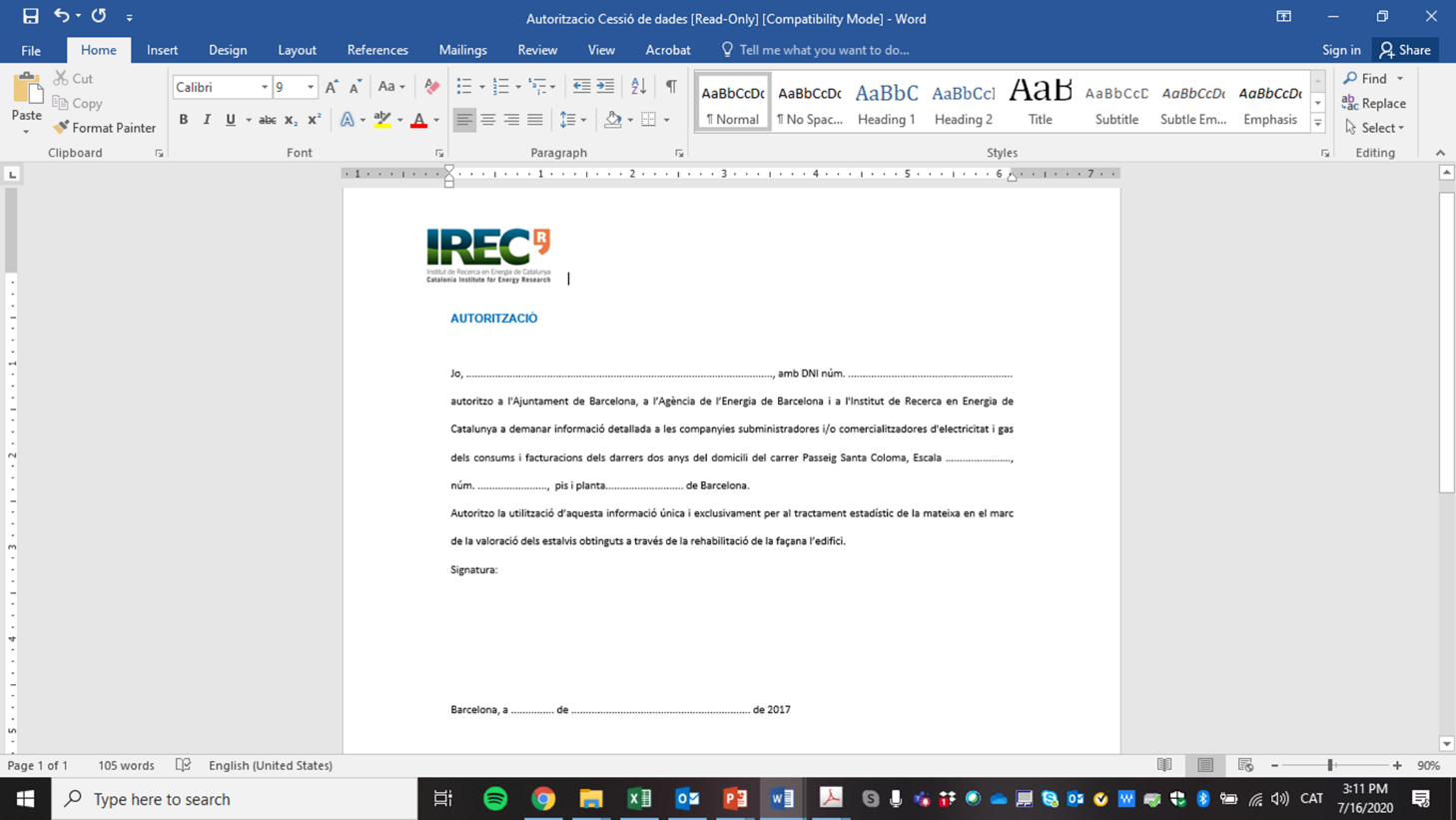


Figure 3. Template of data protection from IREC



Once the equipment is back at IREC, technicians will collect all the data from the different devices and sort them in a unique common file. Even so the collected data will be stored including too the specific characterization of the related households (that is, the household address), none of the expected outcomes of this process will specifically include it. This kind of information will be used only to cross the data with the information coming from the surveys (if any), and to characterize the different case studies for the internal calculation and interpretation of the results.

For such possible cases, the two-week monitoring process would be introduced, at least, twice, considering pre and post EmpowerMed interventions and/or the different yearly seasons. This will be proposed form the starting point to the households that volunteer.

# Data analysis and processing

The collected data will be used for several purposes:

* to analyze the current status and the impact of the planned interventions,
* to fix the hypotheses needed to adjust building simulation models to obtain reliable results, and
* to offer to the end-users oriented strategies on how they could improve their thermal comfort conditions, which should also impact on health benefits.

Thus, the collected data will be initially analyzed and later on post processed.

## Initial data analysis

Initially, IREC technicians will review all the collected data, considering:

* to check and find the main figures (maximum, minimum and average values, also compared with the outside conditions).
* to check the robustness of the data to be used for the main purposes, and
* when possible, to cross the information with the end-users’ surveys or smart-metering DIY tool also developed by IREC and presented during the same collective assemblies.

This initial data analysis will provide first outputs to be transferred to the end-users (see section 3), but mainly will allow to ensure that the collected data would be used for the following steps of interpolation and integration of data, allowing for fine-tuning the data.

## Post processing for simulations and analysis on results

From there, the analysis of monitored data will be focused on PMV and PPD indicators, as the main goals of the EmpoweMed Barcelona’s pilot site are related to comfort and IEQ improvement, rather than energy savings. According to ISO 7730, the PMV (Predicted Mean Vote) and PPD (Predicted Percentage Dissatisfied) are related to the thermal sensations of people primarily concerned with the thermal state of the body. This state depends on the physical activity undertaken and clothing, as well as environmental parameters: air temperature, mean radiant temperature, air velocity and humidity.

To complement the collected data, some hypothesis for the PMV and PPD calculation will be used (as the approximation of mean radiant temperature to air temperature monitored, or the assumption of the value for air velocity in the cases where the simplified monitoring process has been implemented).

Finally, the impact evaluation of EmpowerMed measures will consider too synthetic evaluations by using simulation tools with the aim of extrapolating some (Barcelona) local analysis (coming from the monitoring) to the other EmpowerMed locations. These analysis will mainly focus on indoor thermal behavior and comfort conditions for the end-users. At the other side, the analysis allows to evaluate the energy consumptions, from real user patterns and also from optimal use cases; this kind of “normalization” will allow to compare the obtained results with other coming from reference cases.

# Expected outcomes

From the explained methodology and processes, the following outcomes are foreseen:

* a direct return to the end-users on strategies to improve, as much as possible, the thermal and comfort conditions, and
* an internal deliverable on current status, impact of the implemented measures and extrapolation to other localities.

## Strategies for the end-users

From the analysis on the (bi-weekly) monitored data, and the information coming from the surveys and from the (hourly to yearly) archetypes buildings simulations, a presentation on thermal and comfort strategies will be introduced.

The presentation will include, without any detailed reference on the specific volunteers, a picture on the initial status of the households regarding to thermal and comfort conditions. From there, and with the knowledge acquired from the data analysis and simulations, some recommendations and strategies will be introduced, regarding to both, the potential of some of the DIY actions, and the good practices regarding the mechanisms to reduce the discomfort conditions (i.e.: windows opening patterns, HVAC systems profiles, etc.).

The presentation will be introduced to the end-users during a collective assembly and, if considered, would be shared among other potential end-users using other mechanisms (i.e. website).

## Deliverable on current status, measures impact and extrapolation to other localities

The detailed results obtained during the analysis will be collected in an internal report, in order to reliably establish the initial status of the measured households, as well as their improvement due to different implemented EmpowerMed initiatives. Because of that, this deliverable will be a live-document, to be constructed during time, in order to be as useful as possible for all partners.

The document will include the results on PMV and PPD calculation in each household (Figure 4), and its comparison among pre- and post-refurbishment.

|  |  |
| --- | --- |
|  |  |

Figure 4. Example of display of number of people with calculated PMV and PPD falling within categories I to IV for each analyzed space

Four categories of environmental comfort would be distinguished: visual, thermal, acoustic and air quality. Also more detailed figures related to Temperature, Relative Humidity or other measured parameters will be offered for better comprehension on the status.

The deliverable will also include, as a result of the proposed synthetic analysis, a summary table of EmpowerMed measures impact for each involved pilot site. This will allow for a located analysis in each case, and for a benchmarking analysis among locations.

ANNEXES

[Annex 1. Datasheet of one possible sensor 12](#_Toc31717303)

Annex 1. Datasheet of one possible sensor

