

USER MANUAL OF ANN V.3: INI-C

This guide describes the procedures to estimate the annual cooling thermal load for commercial buildings in Brazil, following a Inmetro Normative Instruction (INI-C). A machine learning model developed and tested by the CB3E and LabEEE team is used to predict the thermal load. All these works were developed under the ECV PRFP 001/2019 agreement signed between the Federal University of Santa Catarina and Eletrobrás.

PROCEDURES:

An input file is read by the predictive model, and an output file is generated based on the inputs. To ensure the proper use of the tool, the following files should be in the same folder:

inputs_annv3.csv: This is the input file which is fulfilled by the user regarding the data from thermal zones and the climatic characteristics.

weather_database_for_annv3.csv: This file contains all the climate data for a selection of cities. The user should select the climate data for the city and insert it in the input file.

metamodel_inic_annv3.py: This Python code will run the trained model. Running this code, the program will automatically import the input files and will generate an output file “results_annv3.csv”.

results_annv3.csv: This file contains the outputs generated by the model, with the cooling thermal load density for each thermal zone of the model.

Const: This folder contains the trained model in ONNX format and the file with the training limits.

The trained model doesn't generate the classification of the building. To generate it, it is necessary to follow the procedures described at the INI-C.

1. INPUT DATA

The first step to run the model is to enter all the data into the file “inputs_annv3.csv”. All data should follow the information available for the actual building and the climate data available in the file “weather_database_for_annv3.csv”. There are 62 variables, where 68 are related to the thermal zones and 14 are related to the climate. Each line of the input file corresponds to one thermal zone, and it is read independently for the others. Hence, the number of lines in the input file should correspond to the total thermal zones of the evaluated building.

The following sections describe the rules to properly set the file “inputs_annv3.csv”, describing the limits of each parameter related to the thermal zone and the climate.

1.1 RULES TO PROPERLY FULFIL THE FILE “inputs_annv3.csv”

- It is mandatory to maintain the order of the columns to insert the data into the file. The trained neural network identifies the data following the column order.
- The data adopted should be within the limits and follow the pattern of the metamodel
- The climate data should follow the file “weather_database_for_annv3.csv”.

Note 01: The climate data should be filtered to ensure that only the data from the desired city are selected

Note 02: Since the lines are read separately, it is possible to use the same input file for multiple buildings.

1.2 THERMAL ZONE PARAMETERS

The file “*inputs_annv3.csv*” contains the following columns which should be filled with data related to the thermal zones:

CEILING_HEIGHT: The ceiling height has an interval from 2.3 to 10.0 meters.

BUILDING_XLEN: This is the length of the thermal zone. For perimeter zone should be considered the external length of the zone.

For perimeter zones, the minimum length value is 10.00 and the maximum length is 40.0 meters.

Internal zones should be considered the square root for the total zone area.

Internal zones have a minimum length of 1.0 and a maximum length of 31 meters.

WWR: This input represents the relation between the window area to the wall. The accepted interval for *WWR* is from 0.0 to 0.99.

Note: Internal zones should adopt a *WWR* = 0.

VERT_SHADING: This input represents the horizontal shading angle between the vertical shading element and the farthest point of the window. If it is an internal zone, the *VERT_SHADING* value should be 90°. The accepted interval for *VERT_SHADING* is 0° to 45°.

FLOOR_U: Thermal transmittance of the floor. The accepted interval for *FLOOR_U* is from 1,75 W/(m²K) a 3,75 W/(m²K).

FLOOR_CT: The thermal capacity of the floor. The accepted interval for *FLOOR_CT* is from 130.0 kJ(m²K) to 400.0 kJ(m²K).

ROOF_U: The exposed roof thermal transmittance of the thermal zone. If the zone does not have an exposed roof, it should be adopted the value of the ceiling or floor. The accepted interval for *ROOF_U* is from 0.3 W/(m²K) to 5.20 W/(m²K).

ROOF_CT: The exposed roof thermal capacity of the thermal zone. If the zone does not have an exposed roof, it should be adopted the value of the ceiling or floor. The accepted interval for *ROOF_CT* is from 0.15 kJ(m²K) a 450 kJ(m²K).

ROOF_ABSORPTANCE: The thermal absorptance of the exposed roof. If the zone does not have an exposed roof, it should be adopted 0. The accepted interval for *ROOF_ABSORPTANCE* is from 0.1 to 0.98.

EXTWALL_U: The external wall thermal transmittance. If the thermal zone is internal, it should be adopted a value equal to -6. The accepted interval for *EXTWALL_U* is form 0.25 W/(m²K) to 5.0 W/(m²K).

EXTWALL_CT: The external wall thermal capacity. If the thermal zone is internal, it should be adopted a value equal to -400. The accepted interval for *EXTWALL_CT* is from 20.0 kJ(m²K) to 450.0 kJ(m²K).

EXTWALL_ABSORPTANCE: The thermal absorptance of the external wall. If the thermal zone is internal, it should be adopted 0. The accepted interval for *EXTWALL_ABSORPTANCE* is from 0.1 to 0.98.

INTWALL_U: Thermal transmittance of the internal wall. The accepted interval for *INTWALL_U* is from 0.31 W/(m²K) to 5.0 W/(m²K).

INTWALL_CT: Thermal capacity of internal wall. The accepted interval for *INTWALL_CT* is from 25.0 kJ(m²K) to 400 kJ(m²K).

SHCG_JAN: Solar heat gain coefficient for the window. If the thermal zone does not have a window, it should be adopted 0. The accepted interval for *SHCG_JAN* is from 0.2 to 0.9.

U_JAN: The thermal transmittance of the window. If the thermal zone does not have a window, it should be adopted 0. The accepted interval for *U_JAN* is from 1.5 W/(m²K) to 6.0 W/(m²K).

SHGC_ZEN: The thermal transmittance for roof windows. If the zone does not have a roof window it should be adopted 0. The accepted interval for *SHGC_ZEN* is from 0.2 to 0.9.

U_ZEN: The thermal transmittance of roof windows. If the zone does not have a roof windows, it should be adopted 0. The accepted interval for *U_ZEN* is form 1.5 W/(m²K) to 6.0 W/(m²K).

PEOPLE: This value will follow the values available in tables from Annex A, from INI-C. The value provided by the INI-C is in area/person and should be converted to people/area to be adopted by the input file "*inputs_annv3.csv*". The accepted interval for people is from 0.03 people/m² to 1.0 people/m²

E.G: For thermal zones in which the main activity is offices, the INI-C Annex A shows a value of 10 m²/person. To enter this data into the input file, we adopt the inverse (1/10) and convert it to decimal: 0.1 people/m².

LIGHTS: The light system density for the thermal zone. The accepted interval for lights is from 3.0 W/m² to 40.0 W/m².

EQUIP: The equipment density for the thermal zone. The accepted interval for equipment is from 3.0 W/m² to 60.0 W/m².

PAZ: The ratio between the roof window area and the exposed roof. If there is no exposed roof, it should be adopted 0. The accepted interval for *PAZ* is from 0 to 5%.

SUR_ANGLE: The obstruction angle from the nearby building to the thermal zone floor. It should be considered only the vertical angle. For internal thermal zones, it should be adopted 90°. The accepted interval for *SUR_ANGLE* is from 0° to 84°.

SDH_ANGLE: The vertical shading angle from a horizontal shading to the window base. For internal zones, it should be adopted 90°. The accepted interval for *SHD_ANGLE* is from 0° to 89°.

SCHEDULE_SCH_8H;SCHEDULE_SCH_10H;SCHEDULE_SCH_12H;SCHEDULE_SCH_16H;SCHEDULE_SCH_24H: These options will define when the thermal zone is occupied. Only one of those options should be equal to 1, representing the occupancy schedule for the thermal zone. The others should be 0.

Is_1pvto_0; is_1pvto_1: this option will check if the thermal zone is at ground level (*IS_1PVTO_1* = 1) or not (*IS_1PVTO_0*=1). When one of these inputs is equal to 1, the other should be equal to 0.

Floor_exp_0; floor_exp_1: this option will check if the floor is exposed (*FLOOR_EXP_1* = 1) or not (*FLOOR_EXP_0* = 0). When one of these inputs is equal to 1, the other should be equal to 0.

Roof_exp_0; roof_exp_1: this option checks if the roof is exposed (*ROOF_EXP_1* = 1) or not (*ROOF_EXP_0* = 0). When one of these inputs is equal to 1, the other should be equal to 0.

Apt_near_0; apt_near_1: this option will check if the thermal zone is adjacent to an unconditioned thermal zone (*APT_NEAR_1* = 1) or not (*APT_NEAR_0* = 0). When one of these inputs is equal to 1, the other should be equal to 0.

Is_perimetral_0; is_perimetral_1: this option will check if the thermal zone is a perimeter zone (*IS_PETRIMETRAL_1* = 1) or not (*IS_PERIMETRAL_0* = 0). When one of these inputs is equal to 1, the other should be equal to 0.

APP_ORI_-360: When working with an internal zone, this field should be equal to 1 and the others related to the orientation (APP_ORI_) should be equal to 0.

APP_ORI_0; APP_ORI_45; APP_ORI_90; APP_ORI_135; APP_ORI_180; APP_ORI_225; APP_ORI_270; APP_ORI_315: These options will define the thermal zone orientation, by entering the value 1 for the column representing the thermal zone orientation. When one of these inputs is equal to 1, the others should be equal to 0.

E.G.: If *APP_ORI_0* is equal to 1, it means that the thermal zone is oriented by azimuth 0. If the thermal zone is internal, all values should be equal to 0.

1.3 CLIMATE PARAMETERS

The climate parameters adopted in the input file *“inputs_annv3.csv”* should follow the data available in the file *“weather_database_for_annv3.csv”* for the corresponding city, whose data are based on weather file (epw). Therefore, the following parameters should be the same for all thermal zones of the building located in the same city.

2 RUNNING THE METAMODEL

Once the file *“inputs_annv3.csv”* is properly filled, you should save it in the same folder as the other files. To run the metamodel, just run the code *“metamodel_inic_annv3.py”* and wait for the program to generate the file *“results_annv3.csv”*.

3 OUTPUTS

The output file will report the predicted cooling thermal load in kWh/m². year for each zone. Therefore, the output brings the annual cooling load normalized by the area for each thermal zone present in the input file. The following figure shows an example of the results present in the file *“results_annv3.csv”* in scientific (Figure 1(a)) or general (Figure 1(b)).

Figure 1 – Example results for *“results_annv3.csv”* (a) scientific (b) general

(a) (b)

	A		A
1	1.11E+02	1	110.6306
2	1.07E+02	2	106.7075
3	9.61E+01	3	96.09818
4	1.04E+02	4	104.3209
5	8.65E+01	5	86.54469
6	5.11E+01	6	51.11848
7	4.93E+01	7	49.31112
8	4.93E+01	8	49.32768
9	4.91E+01	9	49.07158

Since the outputs presented in *“results_annv3.csv”* are the thermal load density, it is necessary to further analyse using the area for each thermal zone to properly evaluate the building.