Notes about the Design Project: Thermal Balance Report

Thermal balance definition

Thermal balance occurs when the sum of all the different types of heat flow into and out of a building is zero. That is, the building is losing as much heat as it gains so it can be said to be in equilibrium.
To establish the thermal balance, we need to identify the different sources of heat losses and gains, in order to sum them up in an equation:

$Q_i + Q_c + Q_s + Q_v + Q_e$ = change in heat stored in the building, nil if thermal balance exists, where
Q_i = internal heat gain or loss resulting from internal heating or cooling sources = primary heating/cooling (active heating, air-conditioning) + secondary heating/cooling (people, appliances…)
Q_c = conduction heat gain or loss when outside or inside heat flows through the envelope
Q_s = solar heat gain when additional heat is provided by solar radiation
Q_v = ventilation heat gain or loss when outside air enters the building
Q_e = evaporative heat loss when water is changed into vapor (typically if you have a pond in your building to help cool it down)

This equilibrium actually strongly depends on the season and is usually assessed for a whole year to be statistically valid.

Application to design project

For your design project it will be assessed only for a given period: beginning of March and over a representative period of 24 hours considered as a sequence of 4 separate time intervals:
- morning conditions
- mid-day conditions
- afternoon conditions
- evening and night conditions (no solar irradiation, no appliances running, no one in the building (except if residential housing)).

For each of these 4 periods, we will consider the conditions as steady-state i.e. both indoor and outdoor conditions fixed to reasonable average values for this time of the year and this location.
Therefore, you will have to determine reasonable indoor and outdoor temperatures, solar irradiation values (for each façade and accounting for obstructions) etc for each of these 4 periods and keep these as fixed parameters.

Typically, we will be in a heating period i.e. it will be colder outside than inside, therefore Q_i will be positive, Q_c negative, Q_s positive (always), Q_v negative and Q_e negative (always).

The idea in your design project will be to determine the active heating or cooling requirements knowing what is gained and lost passively, i.e. determine the "primary heating" component in the Qi term that will make the sum equal 0.

Practically, you will have to identify and assess the different sources of heat gains and losses, using the heat transfer and ventilation equations we have studied, the tables and data sheets provided in your textbook or found in literature, and the information you found on your particular building from various resources.
More specifically, you will, for each of the 4 time periods:
- for Qi: estimate the heat input provided by the average number of people living in the building (depending on what they do there), and the appliances (computers, …) and lights (depending on the type of luminaires), knowing the indoor temperature and humidity
- for Qc: knowing the materials that make up the building envelope and the windows (wall layers, frame and glazing), estimate the heat transfer to get a total heat loss accounting for each one's area and the temperature difference between the inside and outside of these walls/windows
- for Qs: knowing the orientation of the different façades and, roughly, the obstructions created by the surroundings (and a sun course chart to determine the impact of these obstructions on the actual irradiation[1] as well as the time periods they will mostly affect), estimate a reasonable value for solar irradiation and, knowing what the windows are made of, the solar heat gain we get through these windows
- for Qv: knowing the volumes involved and the recommended air renewal rates, maybe also accounting for air leaks or wind conditions if relevant, estimate the heat losses due to air movement
- for Qe: as you probably don't have enough information about the building to assess the heat loss due to evaporation, we will just neglect this term

Once you have an approximate value for all these terms, you will be able to estimate the heating requirements for the building you have chosen.

Don't worry if you cannot get precise numbers. Once more, what counts is only to have the right order of magnitude and to base your conclusions on correct suppositions and method.

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[1] The impact of obstructions on the actual irradiance will also depend on the average weather conditions: if the weather is mainly overcast in early March, the positioning of the obstructions in relation to the sun course will not be as important as if it's mainly sunny. So some rough correction factors can be guessed.