Computational Materiality in the Early Stage Design for Sustainable Architectures

Assignment Guide

ENERGY MASS OPTIONEERING

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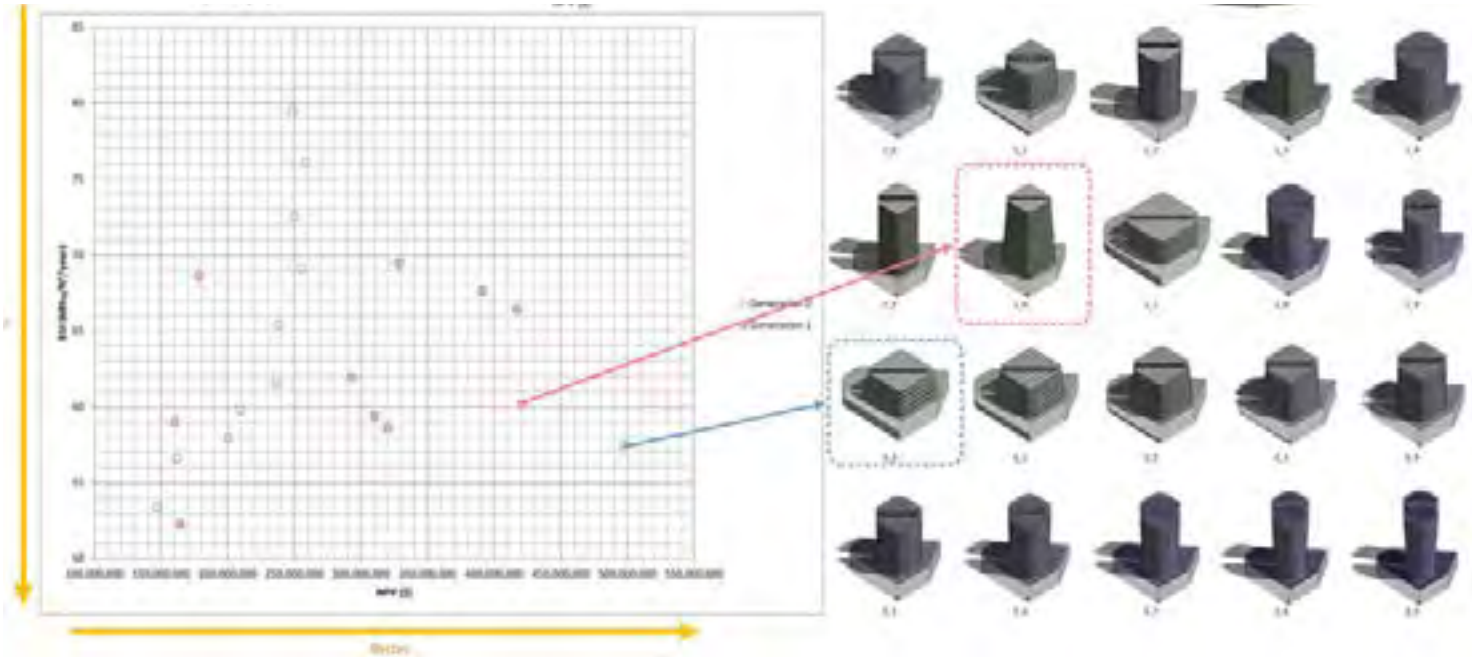


R. Kane, Rifugio d'alta quota sulle Alpi Apuane

ENERGY MASS OPTIONEERING |

Passo Focolaccia. Rifugio alpino in una cava
geographic coordinates: 44°06'04.45" N 10°12'59.48" E

Wheather Station: Monte Cimone

"Our work is about exploring alternative worlds as a means to understand our own world in new ways...through real travel to extraordinary and alien landscapes, exploring the specters of nature and technology and the way they're becoming indistinguishable. "

-Liam Young, Tomorrow's Thoughts Today

1_What to Do.

This assignment concludes the activities aimed at the preliminary definition of the project. For that task students are required to process and compare some volumetric alternatives of the preliminary solution in order to highlight the most effective changes and/or adaptations from an energy point of view in accordance with the functional organization.

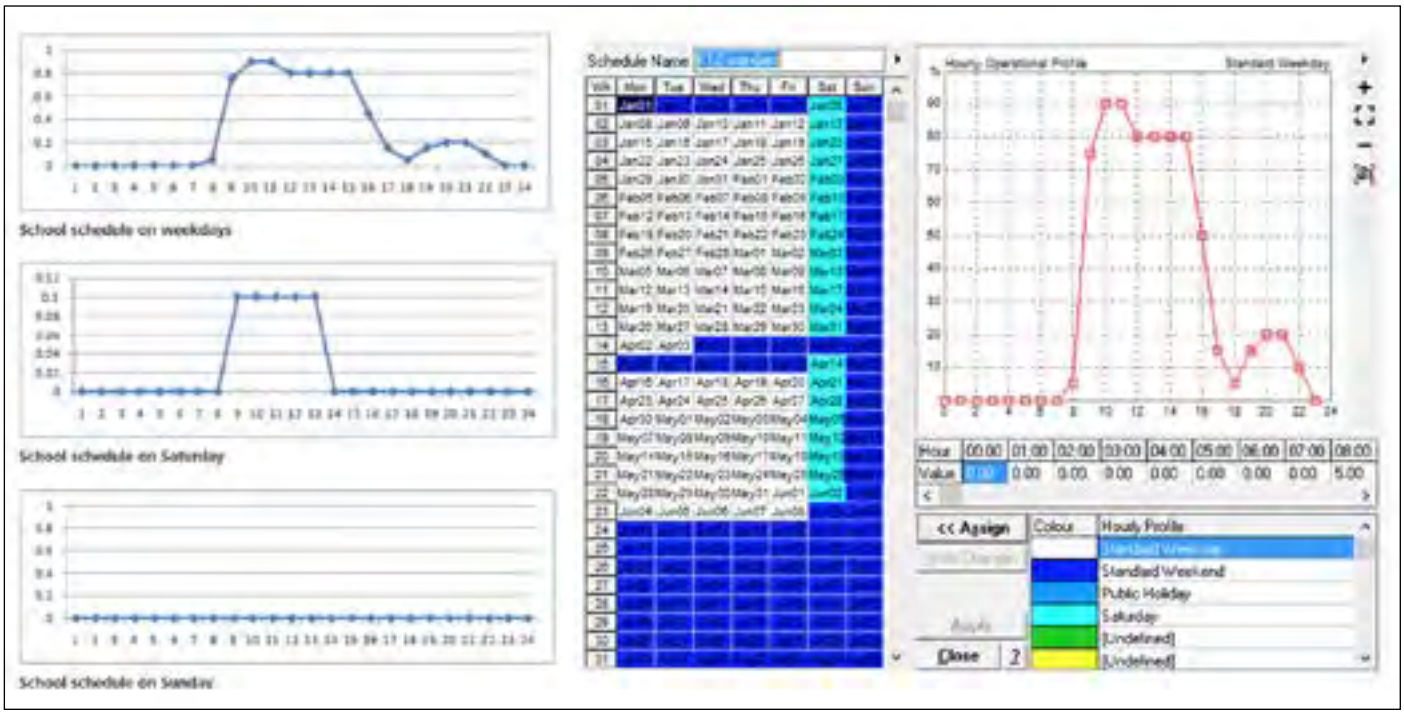
The aim of the exercise is to develop awareness of the influence of the morphological determinant of the architectural buildings on energy performance and environmental quality. Consistent with the philosophy of the course, it is required to give evidence through a clear formalization / communication of the decisional processes, variables considered, and results obtained including the most effective solutions. In this sense, the exercise requires the use of computational procedures to extract and quantify meaningful 'data' of the phenomena, to calculate and to compare values, and to visualize / materialize their results.

2_ How to Do

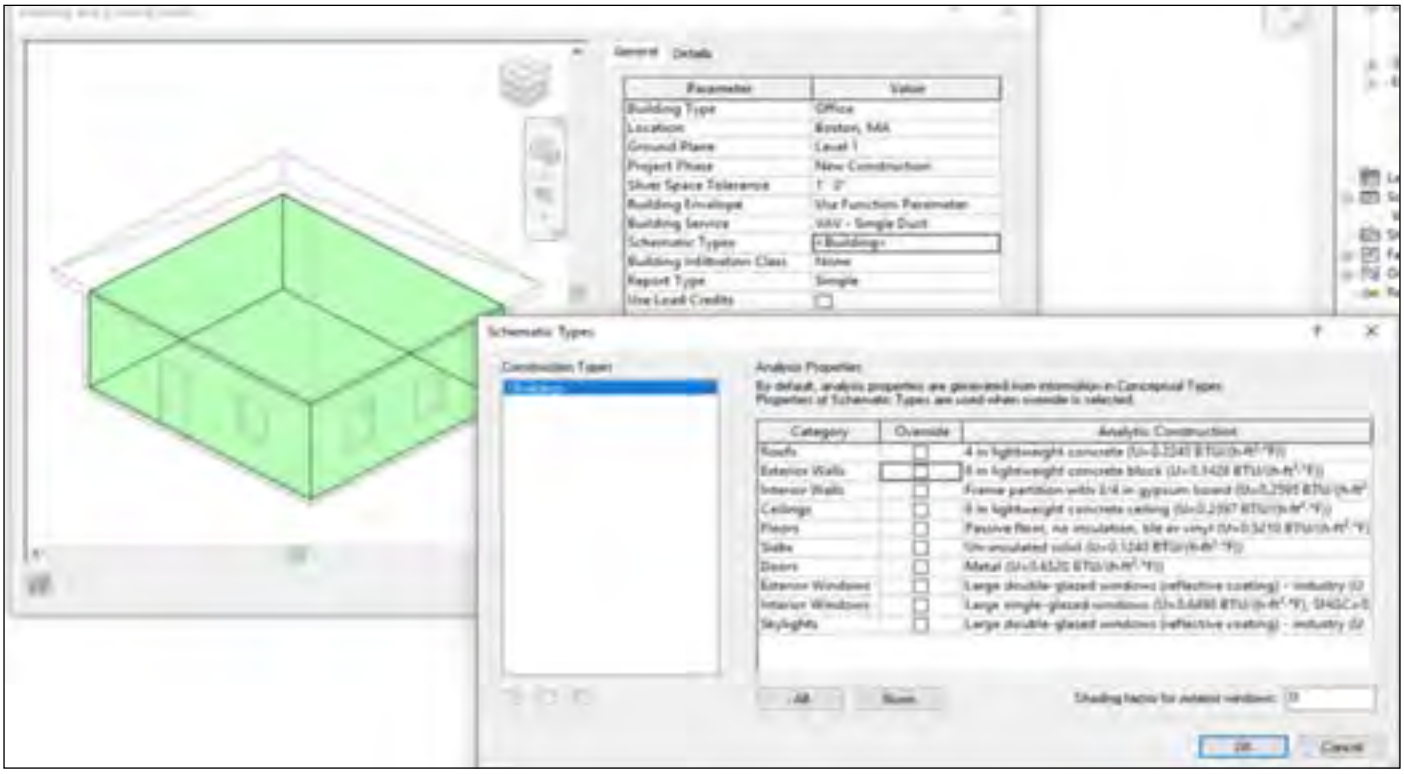
Students, individually or in small groups, are required to develop a series of conceptual mass-level design alternatives (LOD 200), excluding, in the first step, technological variations and to conduct a energy / environmental assessments and comparisons in order to indicate the most effective solutions and strategies.

The following procedure is suggested:

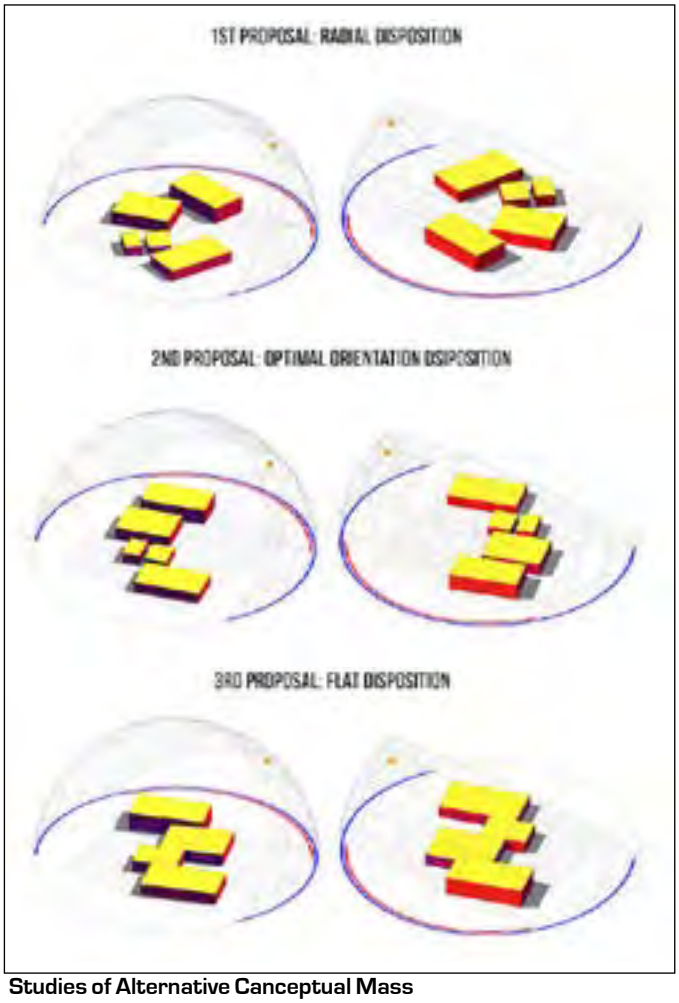
1. Georeferencing the building and identifying the climate station with similar characteristics to the project site, such as the territorial proximity, the altitude, characteristics of the site,..
2. Indicate the intended use of the building and the space occupation program. This last variable is automatically defined by the energy simulation software and can therefore be extracted and displayed by the appropriate sections of the software used. Eventually and if the default occupation does not meet the needs it can be appropriately modified. In any case, do not change these values during the analysis of the alternatives.



Occupancy Scheduling



Default Envelopes Construction in Autodesk Revit

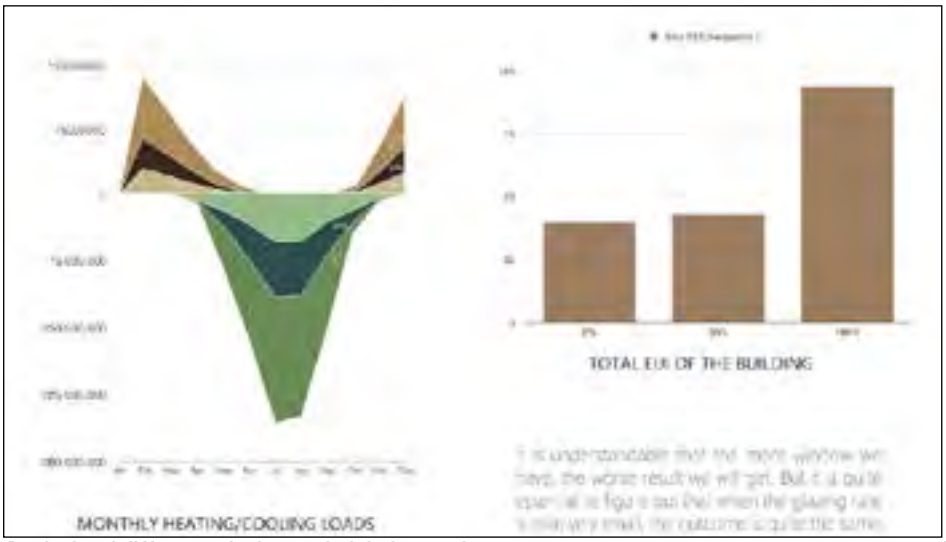


Studies of Alternative Canceptual Mass

3. Run a preliminary analysis on generic conceptual masses (*archetypes*) keeping unchanged technological features of the buildings alternatives. These characteristics are assigned by default in relation to the functional destination defined in the previous point. In order to run a comparative analysis it is essential to exclude any energy contribution due to renewable technologies such as photovoltaic panels, solar panels, wind turbines! For this preliminary analysis Revit and its energy section such as Insight and Green Building Studio is suggested. Comparisons between alternative archetypes and with properly selected benchmarcks will have to be conducted using the EUI - Annual Energy Use Intensity in KWh / sq.m / year!
4. Having selected some preliminary archetype solutions, the subsequest step should focus on breaking down the generic architectural volume in order to identify their vocational passive thermal behaviours (the 3D-Building Thermal Map) as a reference to allocate – in the subsequent step – each functional areas in congruity with its thermohygrometric characteristics.
5. For this task HoneyBee+LadyBug software is recommended following the instructions described in the users guide at https://www.mailab.biz/bes-

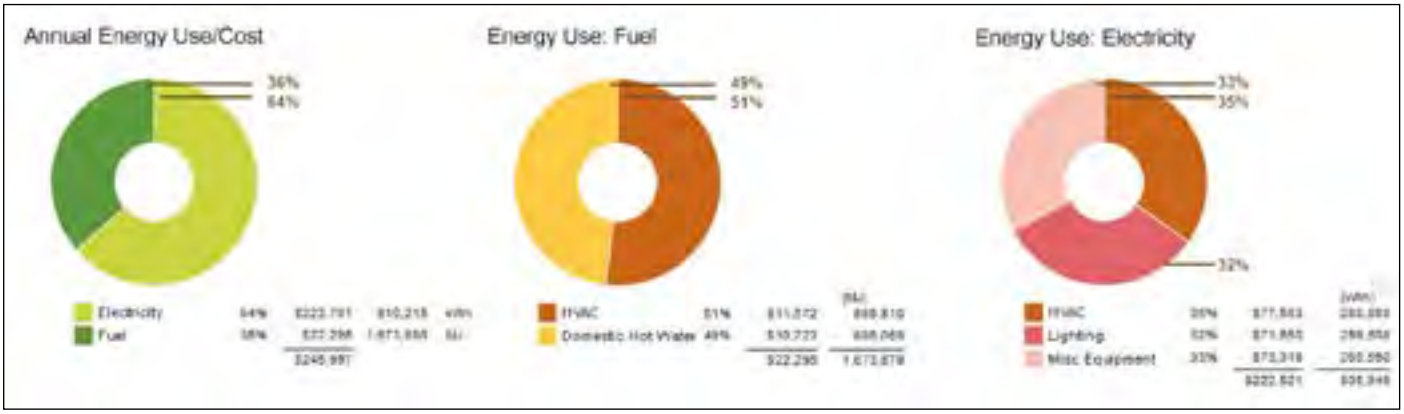
based_mass-optioneering/. Even Revit and Open Studio software can be effectively used taking care, however, to decompose the generic conceptual mass into significant thermal blocks from which it will be possible to obtain a thermal map showing their Solar Operating Temperatures coming – only – from solar contribution! This means that any mechanical system, occupants and equiments should be excluded and, as a consequences, storage (or similar destinations) should be set in each thermal blocks as a functional destination.

6. With the information gathered in the 3D Thermal Map reorganize properly your final solutions locating 'cold' functions in lower Operating Temperatures blocks and 'hot' functions in higher Operating Temperatures blocks.
7. For the last step the energy analysis can optionally be carried out on the reorganized model or on further models if more satisfactory alternatives have been identified. For this final analysis the building must be modeled by attributing the actual functional destinations and the on/off set points of the heating and cooling systems in accordance with the thermal requirements identified in the previous exercise. For this simulation is recommended to use the patch *Thermal energy demand on masses layout model* available at: http://www.mailab.biz/wp-content/uploads/4.GRASSHOPPER_PATCHES/022.Mass_Therm_Option.gh.



Analysis of different glazing ratio isi alternative

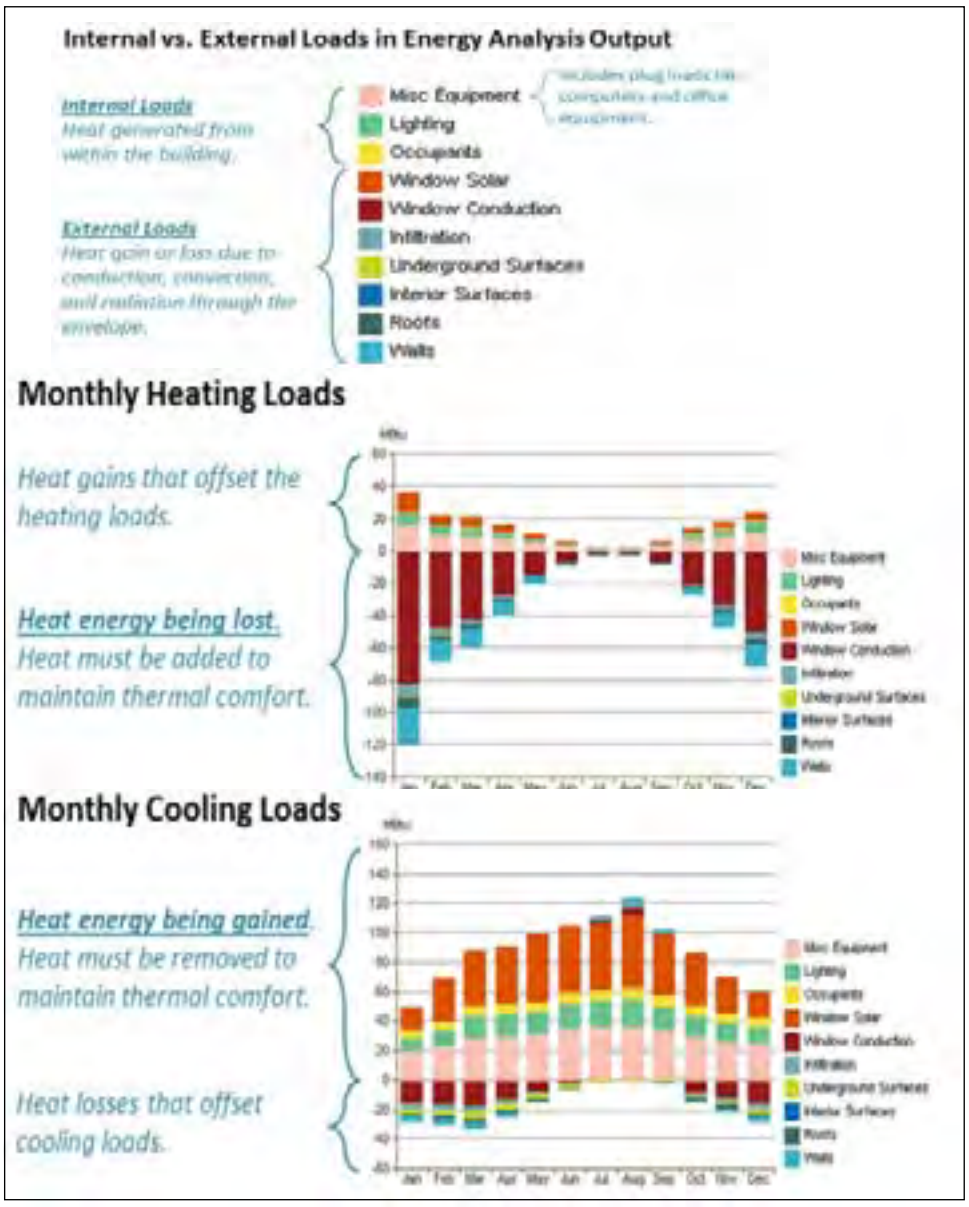
Annual Energy Unit Intensity - Benchmarking



Visualization of annual consumption in Revit

3_ Outcomes & Evaluation

The results of the exercise must be formalized in two vertical UNI A1 tables where clarity of methods and presentation of the final results as design recommendations for the subsequent levels of design development will be the main aspects of the assignment evaluation.
The two boards should contain the elaborations indicated in the previous paragraph, taking care to clearly organize the analysis process, the results obtained and the relative considerations about the negative and positive aspects of each alternative examined.
Consistently, therefore, it will not be necessary to reach the identification of the best solution.
The aim is – instead – to present, in a systematic way, the observations made, the hypothesis about the relationships that exist between the architectural morphology and the energetic behaviors of the building. Their presentation must be carried out by selecting for each solution examined the most significant graphs of energy simulations with addition of comments and schematic ideograms in order to allow a synthetic reading.



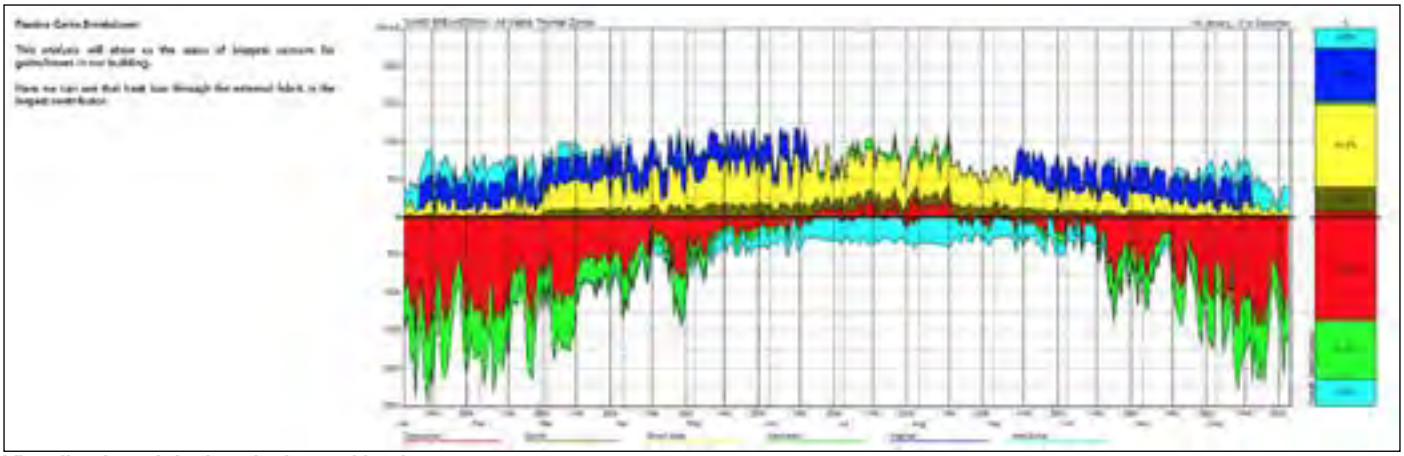
Visualization of the montlhly thermal loads (credit Autodesk)

In detail this report could describe:

- the main condition of the simulation such as geographical coordination, weather station, site morphology as a schematic 3D object where to place models, functional programs and their space & thermal requirements that should invariably be used for each models;
- annual energy consumption attributable to heating and cooling in order to describe the energy profile of the building: if it is *mainly to heat* or *mainly to cool*.
- main components of the annual energy consumption such as occupant loads, lighting, enclosure, glazed surfaces, infiltrations,... in order to better specify the energy profile of the building. The aforementioned components of annual consumption to be examined are: heating fuel, hot water fuel, electricity for air conditioning, electricity for lighting, electricity for equipment. In this analysis very often the fuel is estimated in MJ while the electricity in KWh. The conversion ratio for homogenizing

Figure 5. Heat Loss Locations

Figure 6. Heat Gain Locations



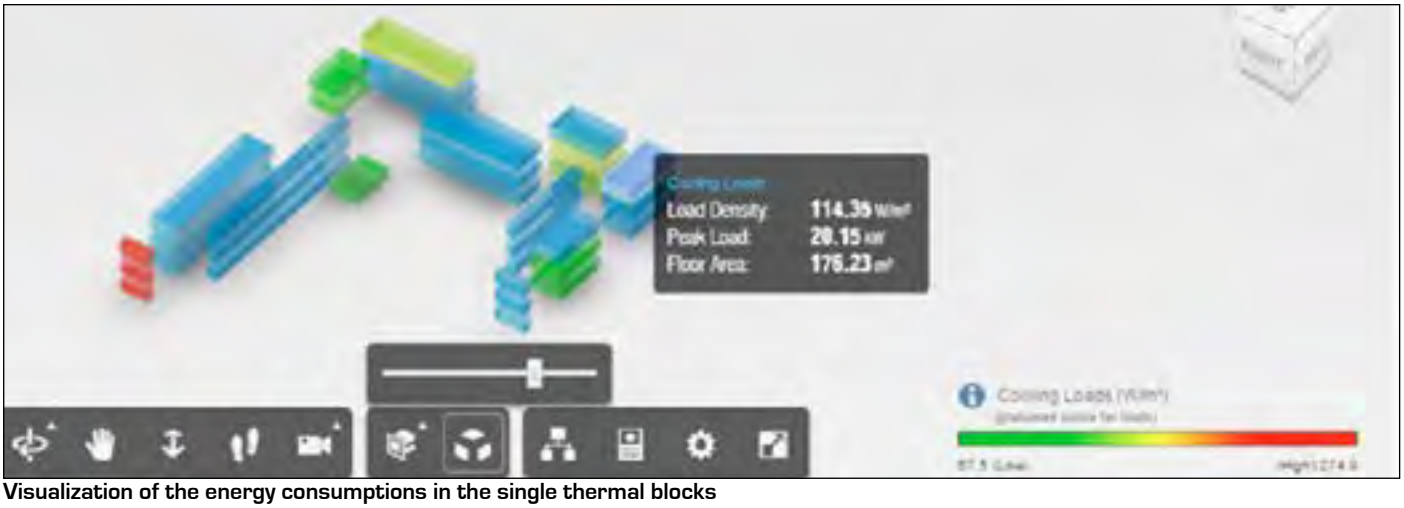
Visualization of the hourly thermal loads

data is 1 KWh = 3.6 MJ. In any case, and for a more effective evaluation, it is recommended to use cost paramter taking into account that, beyond the efficiency of the mechanical systems, the cost of electricity is much higher than heating fuel. In this sense it is suggested – if it is possible –to apply unit market costs acquired from specialized sources for the different enegetic sources.

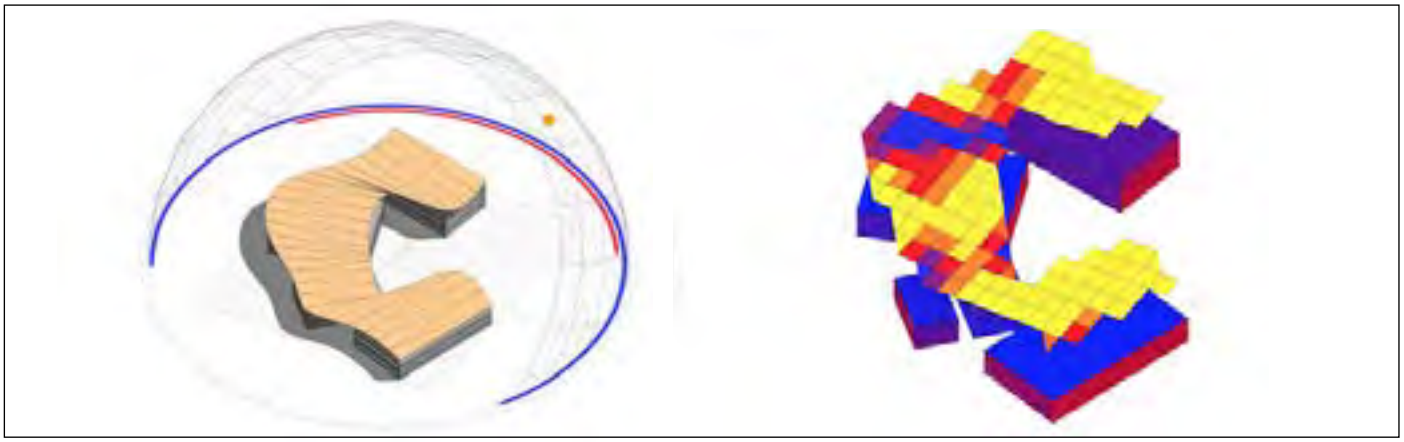
- main form factors showing relationships (positive and negative) that exist between geometric / volumetric determinant and energetic performances including the ratio between the total surface of the building envelope and volume; total surface of the building envelope and useful surface; volume and useful surface.

In addition, the report may also be supplemented by the evaluation of other alternatives that may derive, both in the preliminary and final phases, from a different building orientation, window ratios and from the introduction of contextual elements from which it is possible obtain benefits in terms of shielding from sun radiation and /or winds (walls, artificial bumps, trees, ...).

NOTE: The resolution of the files must be set in order to guarantee the online transmission and to safeguard quality and readability in the printing.



Visualization of the energy consumptions in the single thermal blocks


Visualization of the sun irradiation

useful links

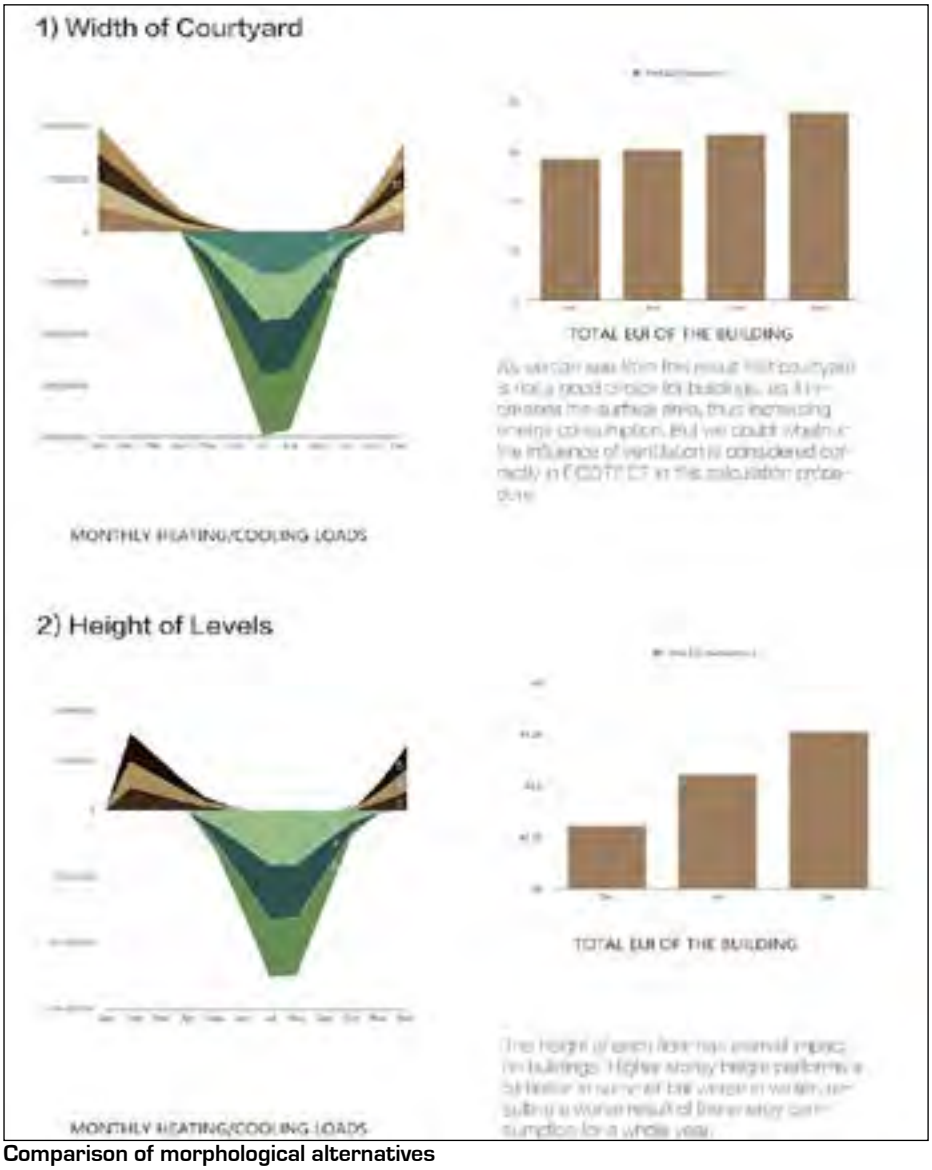
_Modeling Climate and Energy Optioneering
check lectures out in your web class portal at the Lectures section.

_Grasshopper patches
_ https://www.mailab.biz/bes-based_mass-optioneering/

_ Strategy Guideline: Accurate Heating and Cooling Load Calculations
https://www.nrel.gov/docs/fy11osti/51603.pdf

_ Interpreting Revit Energy Analysis Results
https://www.youtube.com/watch?v=lpiGd7Bf11c

_ Thermal Loads
https://sustainabilityworkshop.autodesk.com/buildings/thermal-loads



Comparison of morphological alternatives