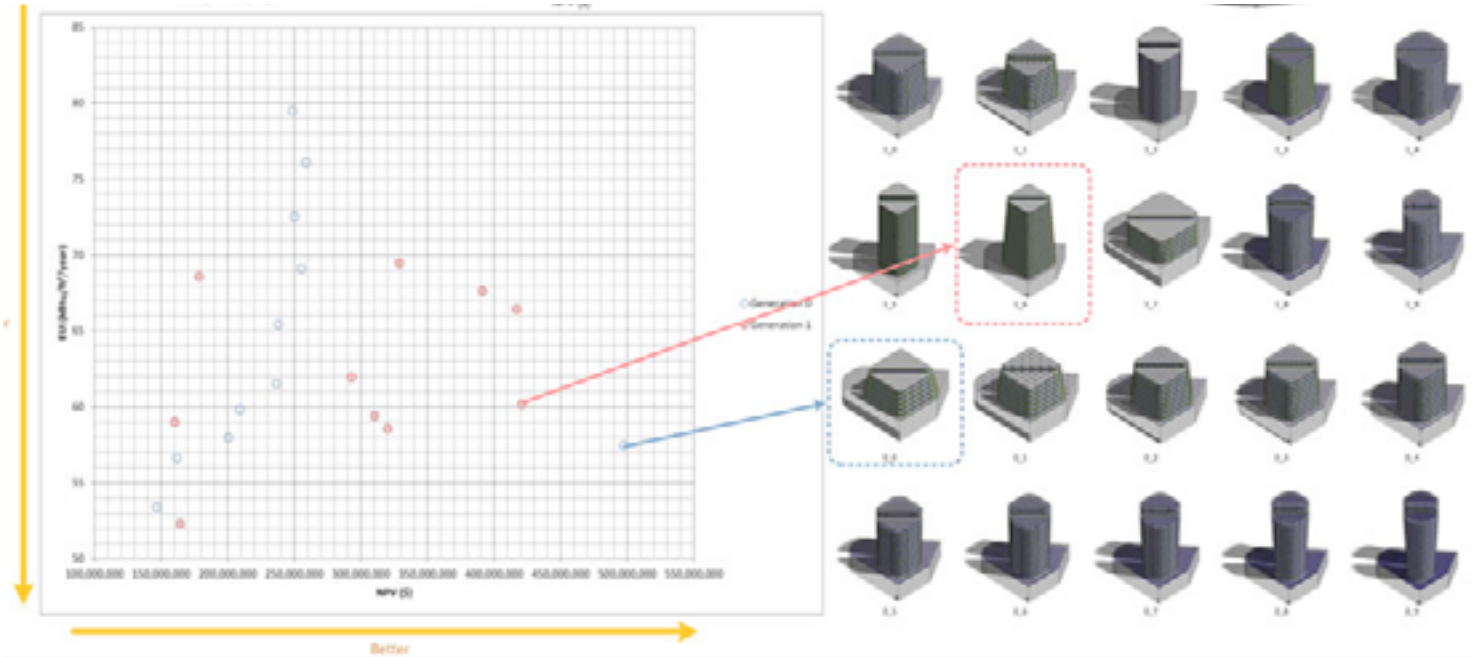
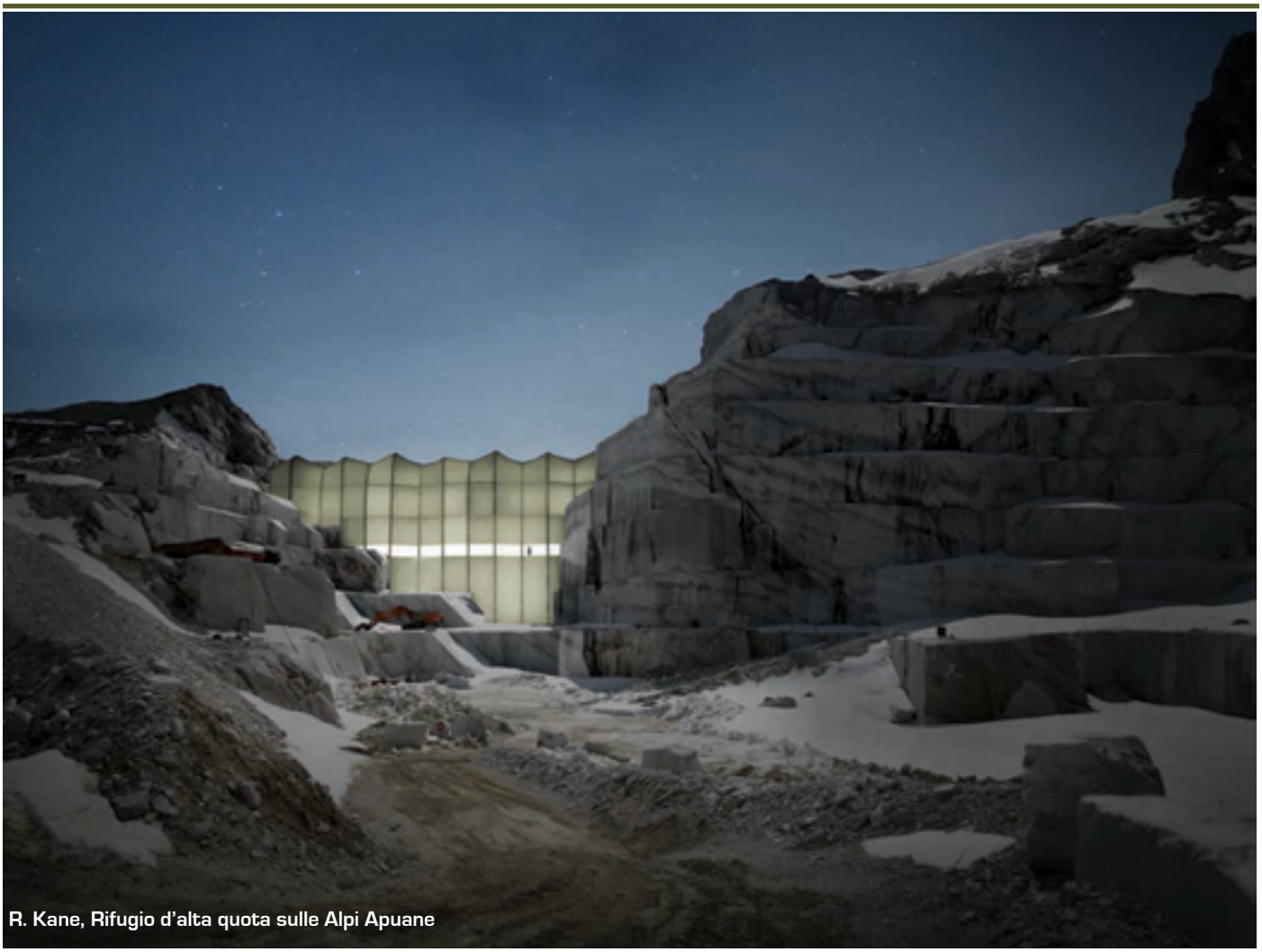
Computational Materiality in the Early Stage Design for Sustainable Architectures

GUIDA ESERCITAZIONE 03

ENVIRONMENTAL MASS OPTIONEERING

Prof. Giuseppe Ridolfi, PhD





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

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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 and, more generally, the environmental one.

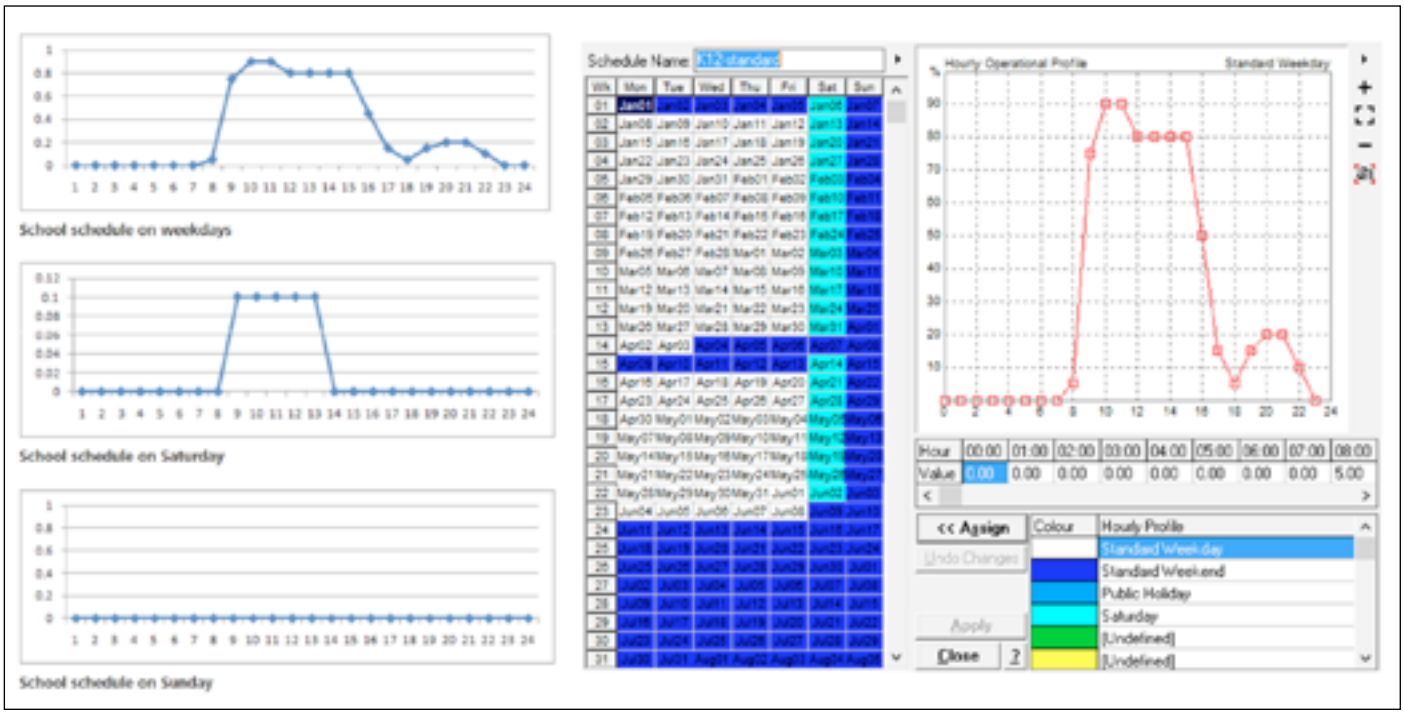
The aim of the exercise is to develop awareness of the influence of the morphological determinant of the architectural buildings on energy performance and environmental quality. Consistent with the philosophy of the course, it is required to give evidence through a clear formalization / communication 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, to visualize / materialize the results.

2_ How to Do

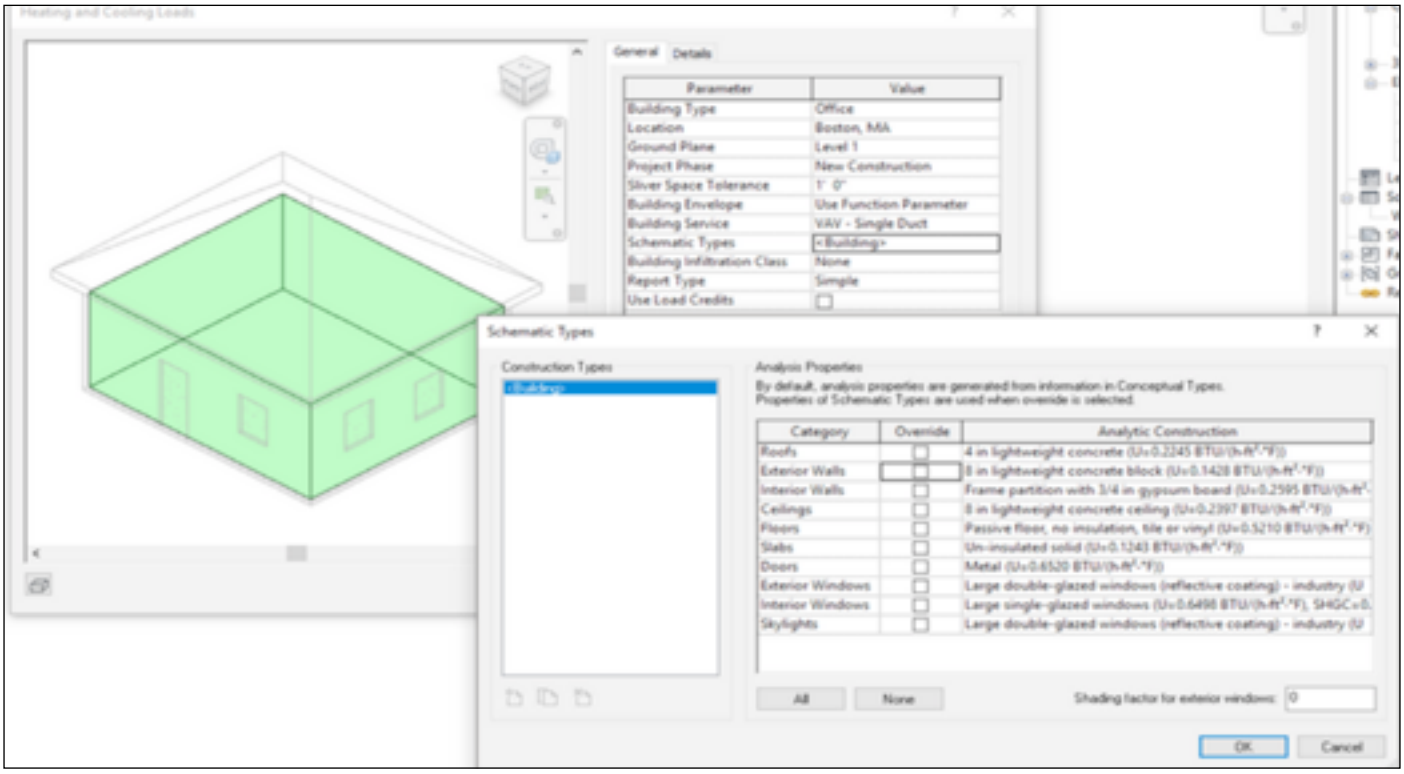
Students, individually or in small groups, are required to develop a series of conceptual mass-level design alternatives (LOD 200), excluding, in the first step, technological variations and to conduct a energy / environmental assessments and comparisons in order to indicate the most effective solutions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

The following procedure is suggested:

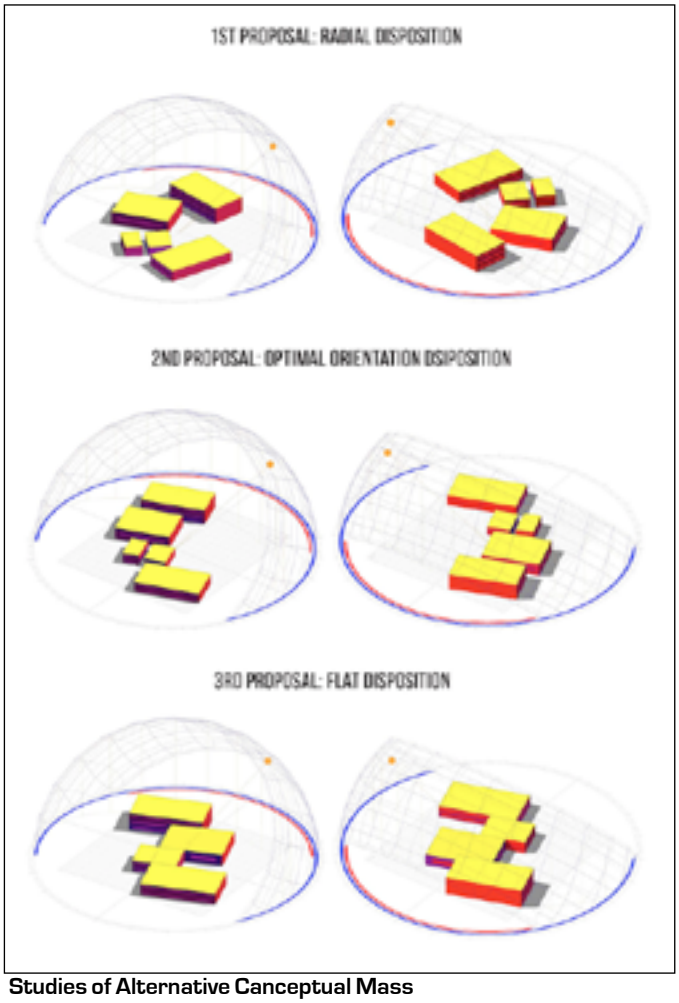
1. Georeferencing the building and identifying the climate station with similar characteristics to the project site, such as the territorial proximity, the altitude, characteristics of the site,..
2. Indicate the intended use of the building and the space occupation program. This last variable is automatically 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 any more during the analysis of the alternatives.



Occupancy Scheduling



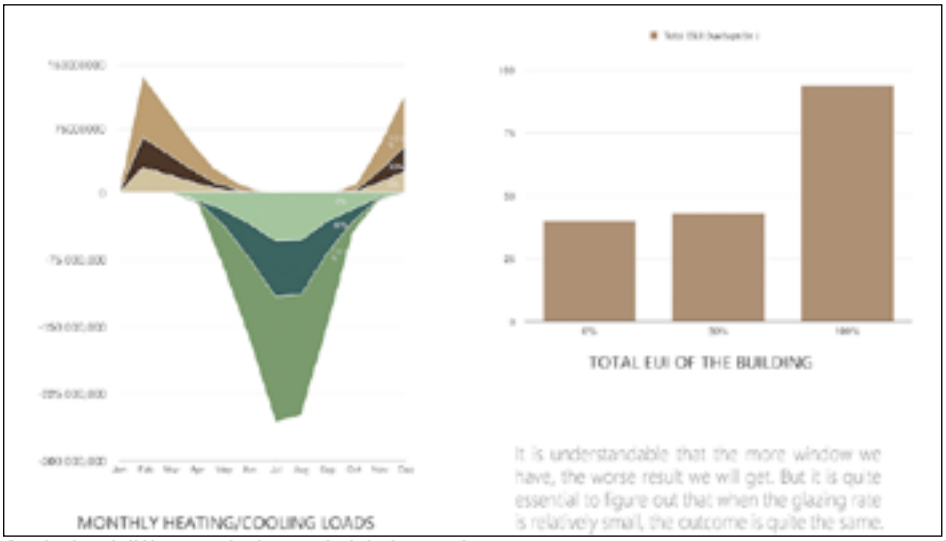
Default Envelopes Construction in Autodesk Revit



Studies of Alternative Canceptual Mass

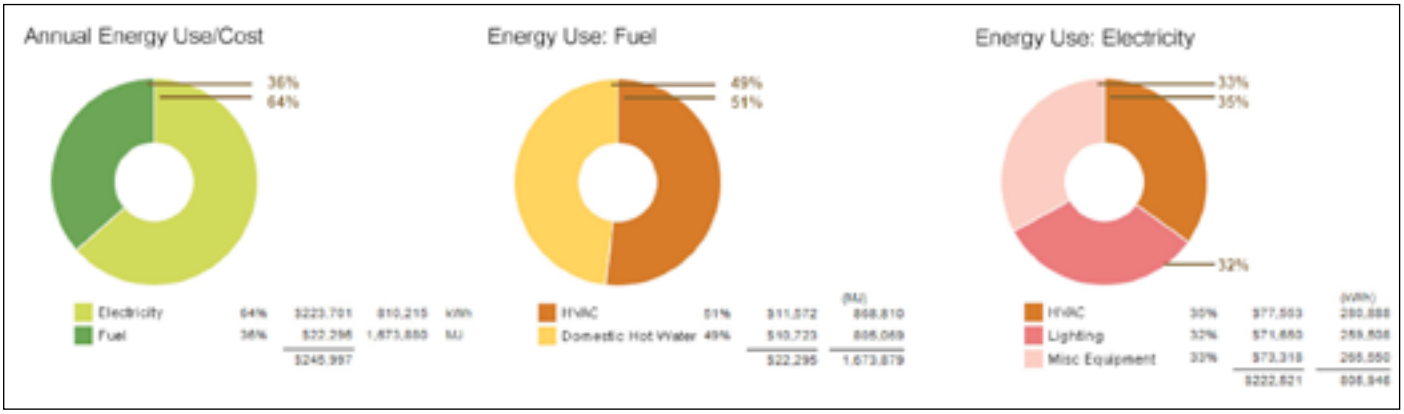
3. Indicate technological features of the building and keep them unchanged for all the alternative solutions. These characteristics are assigned by default in relation to the functional destination defined in the previous point according to the chosen standard. Subsequently, technological specifications can be extracted and displayed in the appropriate sections of the program used. In order to keep the analysis in a strictly passive environment it is essential to exclude any energy input due to renewable technologies such as photovoltaic panels, solar panels, wind turbines, ...
4. Define homogeneous building blocks on the basis of the results deriving from the building program and the environmental requirements. In this sense, building blocks can arise from functional and / or environmental clustering operations by grouping the activities that have affinity and / or continuity with other activities including the outdoors ones(relationship with the outside for entrances, unloading / goods loading, outdoor recreational activities) or those that require the same environmental performance (thermal, lighting, acoustics, sight, ...).
5. Model solutions by assembling or including the previously defined building blocks and rember to keep the model simple as much as possible breaking up complex and / or convex shapes into pure parallelepipeds.

6. Calculate some form factors such as 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.
7. Define and indicate the glazing ratios. Better, if different percentages of glazing are used for different exposures.
8. Calculate the total value of EUI - Annual Energy Use Intensity in KWh / sq.m / year and compare it with some benchmarks.
9. Analyze wich relationships exist between form factors and glazing ratio as define in the previous points
10. Analyze the 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*. Compare these results with what emerged in previous exercises related to the definition of the *Climatic Report* (Psychrometric Chart Anlysis - Outdoor comfort and Standard Universal Thermal Climate Index).
11. Analyze the main components of the annual energy consumption 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 data is 1 KWh = 3.6 MJ. In any case, and for a more effective evaluation, it must be taken into account that, beyond the efficiency of the mechanical systems,



Analysis of different glazing ratio isi alternative

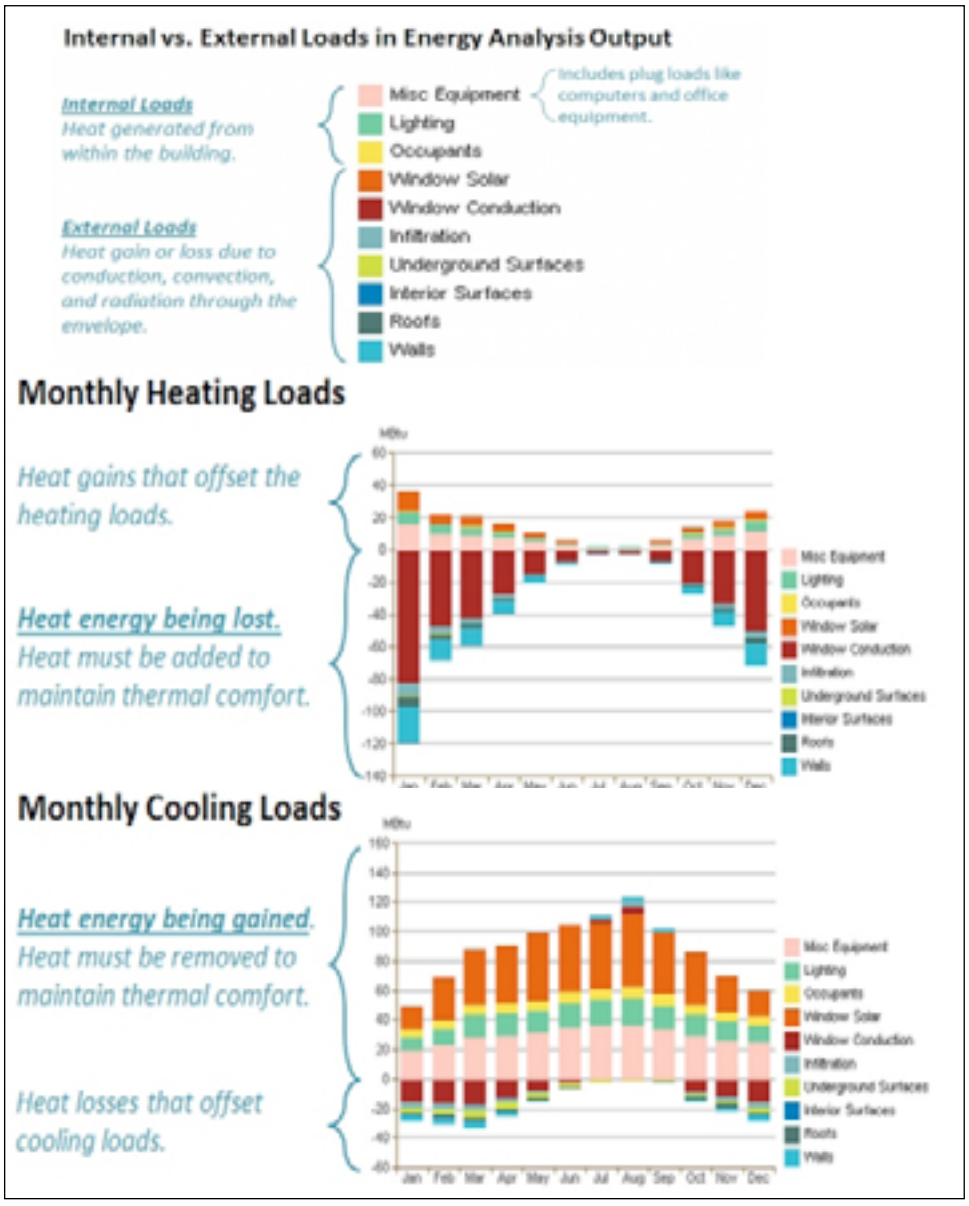
Annual Energy Unit Intensity - Benchmarking



Visualization of annual consumption in Revit

the cost of electricity is much higher than heating fuel. In this sense it is suggested to apply unit market costs acquired from specialized sources for the different enegetic sources and to compare the total annual costs per square meter of the various project alternatives.

12. Analyze and describe the negative and positive contributions (energy loads / thermal loads) that are most relevant to the building's energy behavior, such as: occupant loads, lighting, enclosure, glazed surfaces, infiltrations. This type of analysis is carried out differently by different sotware. For example, Revit displays the data as shown in the figure which can be difficult to read. These data indicate the amount of energy that is added or subtracted in the energy balance of the building by some "passive" contributions such as people, equipments, walls, windows, ...present in the building. To understand which design actions are required to improve the thermal behaviour of the building look at the Heating Loads table for Winter and identify the highest negative components; vice versa look at the Cooling Loads for Summer to identify the positive components that determine an increase in consumption. In any case, pay more attention to the summer components if the building is *mainly to cool* or to the winter components if the building is *mainly to heat*. An aspect



Visualization of the montlhly thermal loads (credit Autodesk)

not immediately understandable is due to the fact that these loads differ in the same month when they appear in the Heating Loads and Cooling Loads charts. The reason for this difference lies in the fact that this type of analysis derives from engineering practice where heating and refrigerating systems are calculated and sized under the most severe conditions. This means that the Winter most severe conditions occure in the coldest hours, that is at night; vice versa for the Summer, they occur in the afternoon hours. Although in other software analysis and visualization may take place in a different way, these indications are useful to perceive immediately which components have the highest impact on the building consumption.

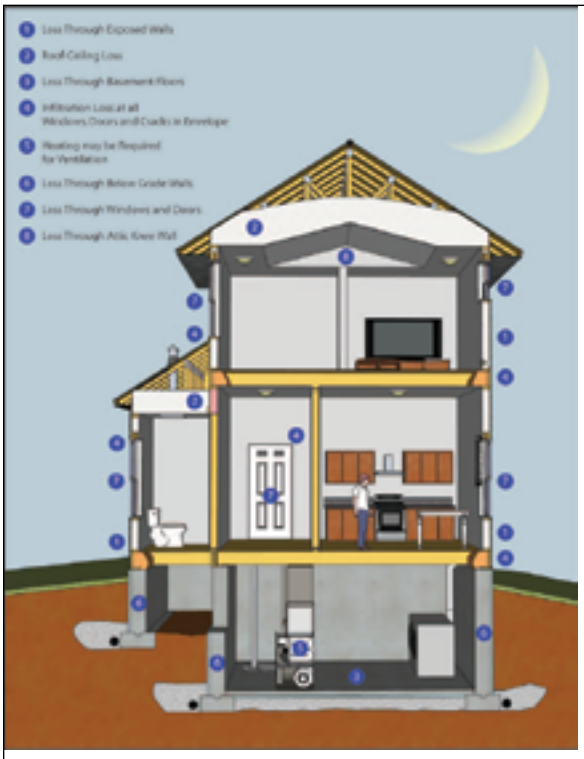


Figure 5. Heat Loss Locations

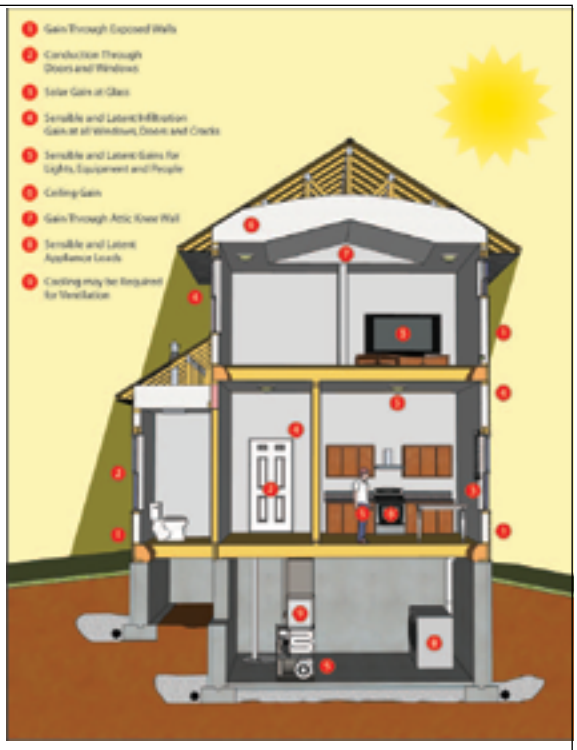
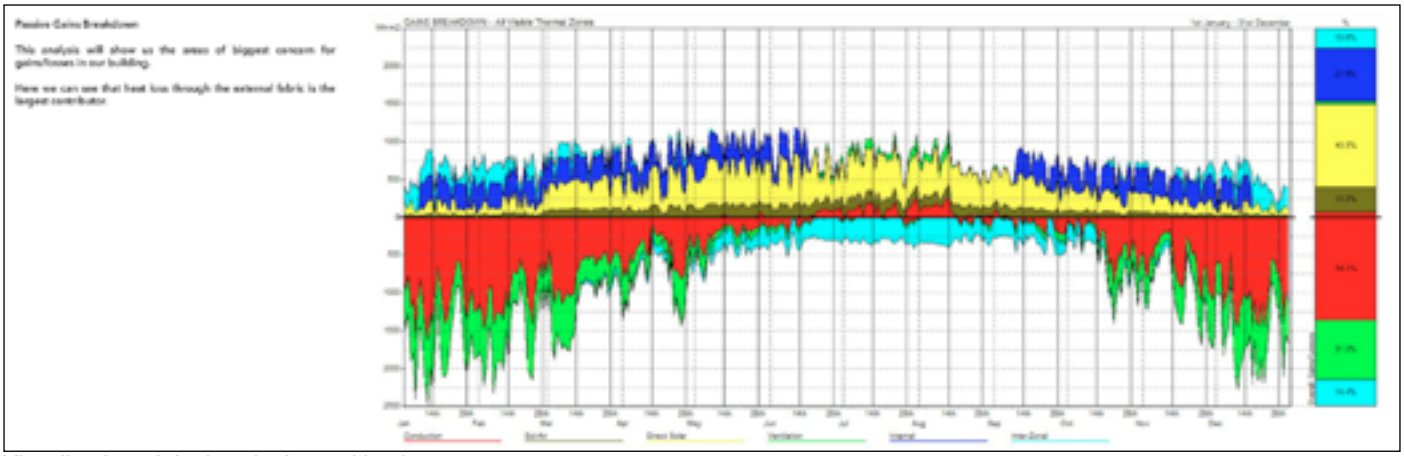
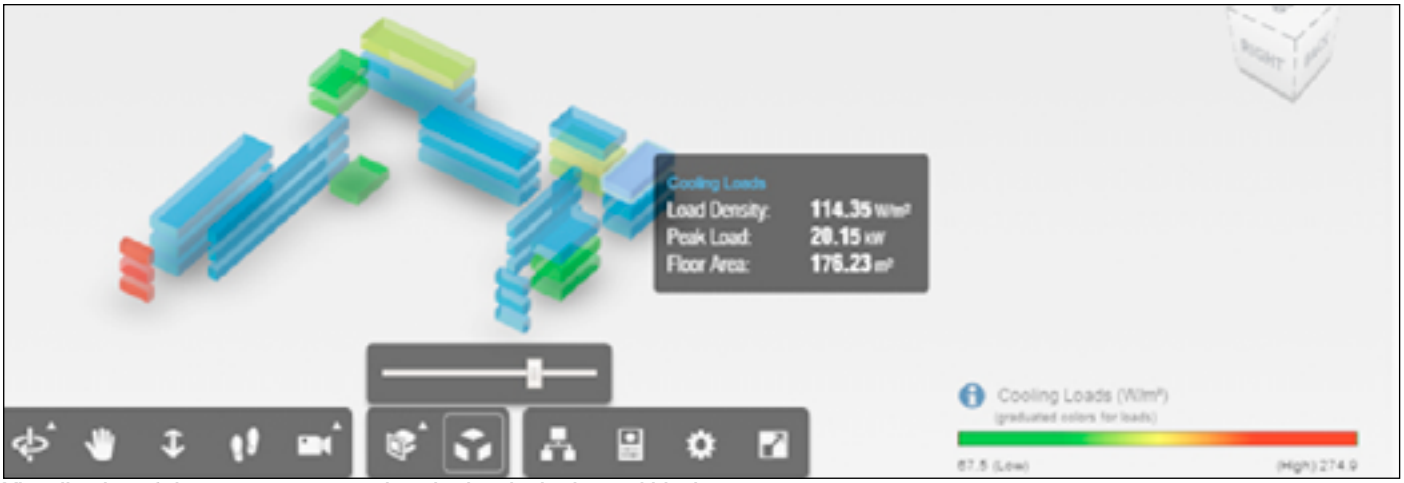


Figure 6. Heat Gain Locations

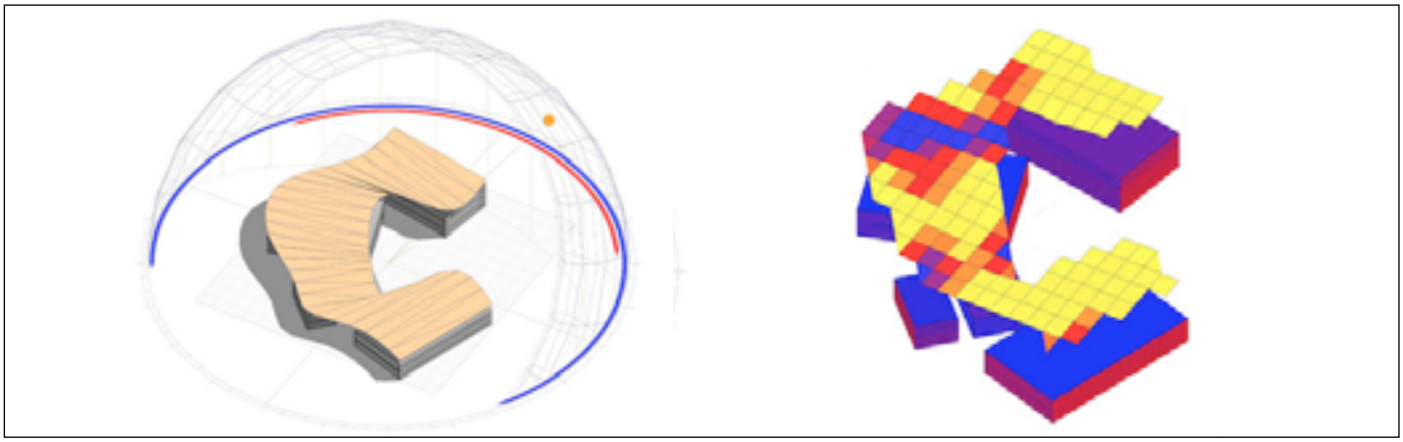


Visualization of the hourly thermal loads

13. Identify the energy conditions of the different parts of the building in order to re-organize the building volume to re-arrange the building blocks in a more compatible way with the indications obtained (eg: placing the building blocks that require lower temperatures in the areas highlighted as colder and vice versa). In this reorganization it's also required to take into account the results generated in the *Climatic Report and the Site* and more precisely in the analysis of the Wind Rose, shadings, ...
14. Select the most significant elements coming out from these analysis and briefly describe, also using ideograms and schemes, the results obtained and the emerging strategies applicable for the subsequent design phases.
15. Repeat the sequences from step 5 in order to obtain different alternatives to compare. These alternatives should include the orientation, the glazing ratios, the introduction of fixed or seasonal shield elements, ..., In any case, besides a different morphological articulation, modifications must be realized without altering the total functional surfaces, In addition and in order to maintain the comparison in a purely passive arena, in this phase it is not allowed to introduce changes to the technological properties of the building.
16. Repeat the sequences from point 5 placing the architectural mass in the selected site and adding the contextual masses such as other buildings, trees, hills,... in order to evaluate/understand their effects.



Visualization of the energy consumptions in the single thermal blocks


Visualization of the sun irradiation

17. Conclude the comparative analysis by preparing a report integrated with schemes and ideograms in order to highlight: the relationships (positive and negative) that exist between geometric / volumetric determinant and energetic performances; design modifications; and/or recommendations.

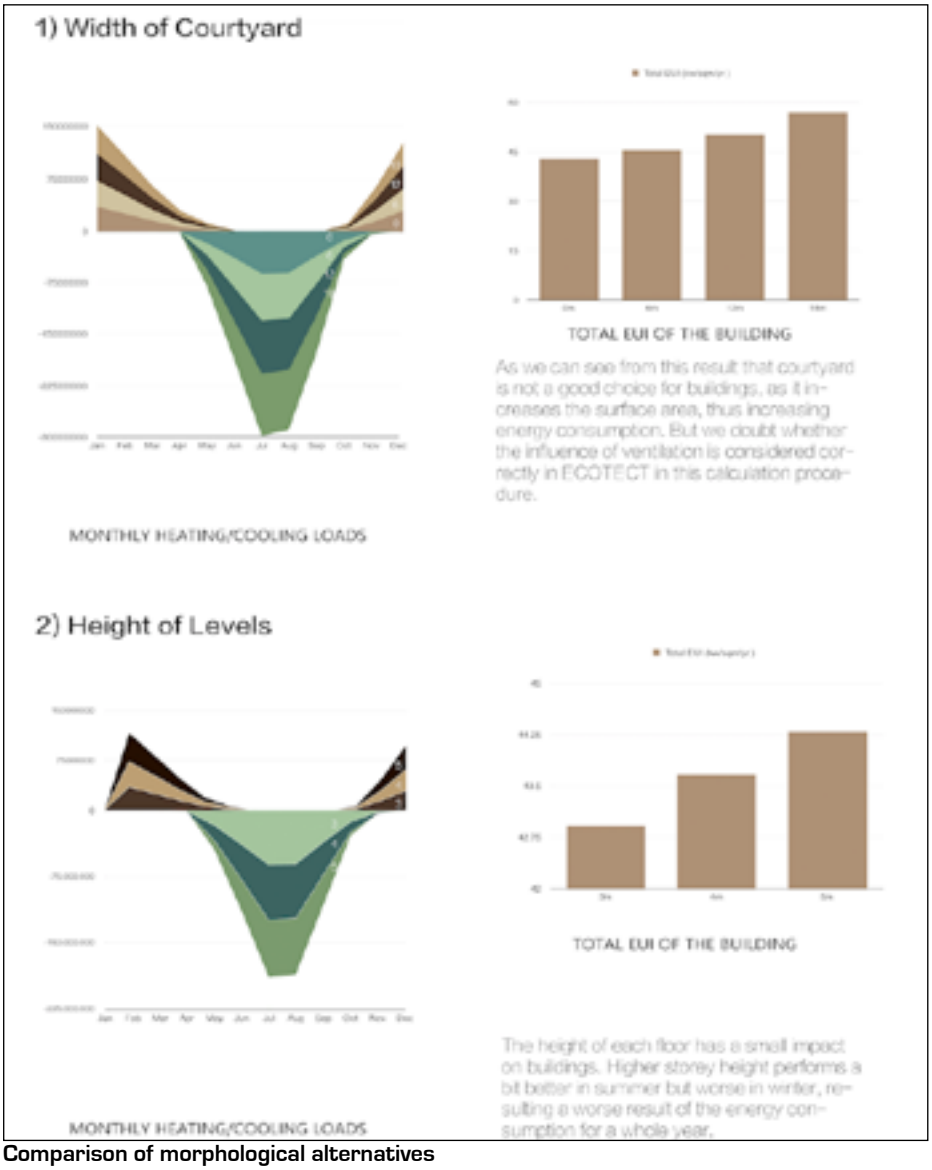
3_ Outcomes & Evaluation

The results of the exercise must be formalized in two vertical UNI A1 tables to be discussed in class for 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.



Comparison of morphological alternatives

The final part of the works must summarize the conclusions where design strategies, solutions and recommendations could be adopted for the subsequent levels of design development. Clarity of methods and presentation of the final result will be one of the main aspects of the assignment evaluation.

18. 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.

useful links

_Modeling Climate
http://www.mailab.biz/wp-content/uploads/LECTURES/004.%20MM&ENV_OPTION_w_REVIT_wm.pdff

_ 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=IpiGd-7Bf11c

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