

## THE SPATIAL DIMENSION OF ENERGIES: URBAN PATTERNS AND ECO-STRATEGIES

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### Abstract

The outcomes of an experimental urban design studio named “Energy and urban Planning” offered to graduate students enrolled in the Urban Planning and Policy Design master programme are presented in this paper. The goal was to recognize the importance of the role that the urban planner can play in assessing both the suitable energy scenarios and the spatial dimension of energies on the territory by introducing a set of disciplinary references and a toolkit for action. A number of tools for the analysis and the design of energy-conscious urban master-plans were offered to students with limited competences on environmental and energy topics.

The case-study area chosen for the design was the metropolitan region of Milan, Italy, characterized by a temperate climate and a variety of morphological configurations, for simplicity grouped in three main categories, namely what we call the Compact City, the Edge-City and the Diffused City. In particular, seven samples of that territory were selected, investigated by seven teams of students, and proposed solutions were given.

Outcomes of the studio show that the contribution of the urban planning discipline can be relevant in assessing alternative energy scenarios, both in terms of quantification and evaluation of design solutions. For instance, taking into account energy and environmental aspects from the beginning of the design process, highly impacts on the concept solutions and the final physical layout of the built environment (in terms of land use and morphology). Hence, energy-conscious urban planning might lead to significant energy savings. Moreover, the scale of action, i.e. the small town or the district level, reveals to be a proper dimension in order to apply urban ecology principles.

### 1. Introduction: objectives of the studio

It is evident that different urban configurations present different energy consumption implications. Which is the contribution of the urban planning and design discipline in addressing sustainable future scenarios for the city is a crucial question. We believe that urban planners’ expertise can inform the debate on energy in three ways as

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follows: firstly, in assessing the spatial dimension of energies within the urban landscape, thus acknowledging the physical layout as a key component of environmental sustainability. Secondly, in measuring and quantifying urban sustainability indicators, according to the increasing demand for evaluation and monitoring of urban policies; thirdly, in proposing innovative design solutions for the built environment (both the fabric and the open areas), which optimize the use of energy and mitigate environmental depletion. This latter aspect should be intended as a long term research perspective aiming at informing the debate on new urban design and planning theories.

The objective of the studio is twofold: first, to provide a basic knowledge on the topic of sustainability at the urban scale (policies and design) and second, to explore possible future scenarios through a design project that intentionally considers the implications of the different urban forms for the construction of site-related strategies and actions (eco-zoning). In particular, we explored two main ways to achieve more sustainable urban environments: one is related to the policies that the city can adopt in order to promote more environmental-friendly practices; the second one is related to the physical design of the urban environment and how this can influence sustainability.

## **2. Research context**

During the class we referred both to the scientific literature and to international policies and standards. In particular, scientific literature gives a global picture of innovative approaches and the rhetoric of different disciplines, whereas policies enable to frame the political context and the targets of our actions for the next decades.

Punctual scientific references on energy come from several areas and the urban planning discipline should extract those relevant clues that have a direct feedback on the practice. One area of interest can be named “urban energy transition” according to the book edited by Peter Droege (2008), and refers to a series of studies focused on energy planning and metabolism towards a renewable, carbon-neutral city. In this sense, the type of investigation is related to the assessment of available and future clean technologies and the policies and strategies of diffusion (Mega, 2010) with a scarce feedback on the physical dimension of the territory.

A second set of references can be grouped under the umbrella of “urban ecology”, which originated from ecology studies (Odum, 1963; Odum, 2001). In particular, the introduction of the Ecological Footprint concept by Mathis Wackernagel and William Rees (1996) was a first attempt to relate ecology to the spatial dimension of human impacts. The more recent debate on sustainability strengthened the issue of the limited natural resources on Earth. However, the concept of sustainable development appears to be contradictory to some authors (Latouche, 2006), who reject the argument of growth in a finite world and support the paradigms of scarcity and self-sufficiency. According to this latter vision, the first aim of the design studio

was to reduce human impact on the territory through energy savings and efficiency, and only in a second step to produce clean energy on site.

Finally, “energy-conscious spatial planning” and “sustainable urban design” represent the most pertinent research contributions for the design studio, because they argue the importance of the urban planning discipline in sustainability issues. A critical approach to recent sustainable urban design contributions was required to students, and the use of tools derived by that research stream were proposed and applied during the studio.

Energy-conscious planning originated from urban ecology considerations, and proposes a physical declination of energy scenarios in relation to the type of territory and the possible synergies and dependencies among different patterns, whereby the built and un-built territories are intended as components of an eco-system that should work – and survive – with closed cycles, stressing off-grid solutions and the reduction of the ecological footprint of urbanized areas. The “Second Law thinking” reminds us that during each transformation, a certain amount of useful energy (i.e. exergy) is transformed to a less useful energy (i.e. entropy), thus we have to save high quality forms of energy (Stremke & Koh, 2010; Van den Dobbelsteen, et al., 2011).

The second discipline is rooted in the New Urbanism and Smart Growth movements (English Partnership with the Housing Corporation, 2000; Farr, 2007; Duany, et al., 2010; Haas, 2012) and reached a large audience and success due to the capacity of structuring a series of sustainability principles related to the physical design of the urban environment, and delivering simple guidelines, rules and certification systems for professionals (U.S. Green Building Council, 2009).

Reference for this work are EU policies promoting effective tools and programmes to achieve sustainability and energy self-sufficiency, in particular the 20-20-20 targets and the recent Roadmap 2050 for a low-carbon Europe. The Covenant of Mayors with the introduction of the Sustainable Energy Action Plans (SEAP) represents a useful framework for addressing objectives, strategies and actions at the urban scale (The Covenant of Mayors Office, 2008). Significant Action Plans delivered by big European cities were consulted and compared in terms of proposed actions and sectors of investment. Nevertheless, we noticed that most of the plans were conceived as guidelines with a lack of urban design solutions and scarce reference to the spatial dimension of the territory in general.

### **3. Case-Study areas**

The metropolitan city represents a mosaic of fragmented urban environments, each of which shows different opportunities in terms of environmental and energy scenarios. In particular, an urban transect crossing three main typologies of settlements was recognized as the object of investigation at the studio. Hence, we distinguished among three types of urban environments: firstly, the Compact City,

i.e. the urban cores characterized by a significant mix of uses; secondly, the so called Edge City, i.e. the in-between places that host relevant services for the management of the entire city and were built without a coherent vision; thirdly, the Diffused City, which represents the flourishing low-density, car dependent sprawl, where land consumption has already exceeded acceptable limits in terms of environmental preservation. Seven teams were asked to work on seven samples of the territory considering the different critical issues and opportunities they have.

For the Compact City, two areas with totally different character were chosen. The first site, the Ortomercato (the wholesale vegetable market for the city) represents the occasion of the conversion of the current function into a new neighbourhood on the east side of the city; the second area, on the other hand, is the re-appropriation of a large surface currently occupied by the freight railroads in the centre of the city, thus primarily reconsidering the reconnection and the renewal of the existing fabric.

The three sample areas selected to describe the Edge-City conditions are not enough to cover the variety of the typologies we can encounter. For sure that is the transect which offers more occasions of transformability, because of its recent history with low value interventions and scarce coherence with the surrounding. The first site is the city waste management headquarter at the east periphery of Milan, a typical troublesome function relegated close to the boundaries of other municipalities. Nevertheless, this portion of the city is still facing an agricultural land, which might represent an opportunity to work with in terms of urban ecology. The second sample is the Baggio district, an old historical nucleus in the west periphery of the city. Dealing with the already established urban fabric with few occasions of redevelopment, forces us to conceive new ideas to achieve sustainability. The last area is a free agricultural site in the municipality of Rozzano, south of the city, where the new city plan expects to build a new high density and mixed uses neighbourhood, with serious problems of connectivity to the existing street network, due to the presence of a canal and two highways on the boundaries.

Finally, the Diffused City was well represented by two areas that show different characteristics. The first area, i.e. the town of Lainate, is the typical urban agglomeration that can be found in the northern part of the metropolitan region. In fact, Lainate is the result of the grouping of different small communities which go without solution of continuity on the territory. Housing and production are mixed; islands of residential neighbourhoods are interspersed with heavy transport infrastructures. The second town, Melzo, on the contrary, is a compact settlement located in the eastern part of the region characterized by a strong agricultural land use.

## **4. Methodology and design process**

### **4.1. Research by design**

The goal of the studio is to come up with a design project at the district or urban scale that envisions possible future scenarios for a number of different cityscapes.

Students are asked to work in groups of three people; each team should be composed by students with different backgrounds, in order to integrate their skills.

Encouraging ‘research by design’ is part of the methodology of the studio. This will be investigated through the introduction of tools for the analysis and the design of future conditions. Students are asked to explore at the same time urban re-composition strategies and the introduction of eco-strategies and actions suitable for each different urban environment.

The series of lectures is offered to the students and has the goal to introduce the topic of sustainability applied to the urban planning and design discipline. The lectures aim at covering the two main topics, namely one is related to the policies that the city can adopt in order to promote more environmental-friendly practices; the second one is related to the physical design of the urban environment and how this can influence sustainability. The first series of lectures is called "Energy, climate change and local action to reduce greenhouse gases (GHG) emissions"; the second one, deals with the topic "Energy, environment and the city form". In particular, the first series introduces the policies (mitigation and adaptation) towards carbon neutral cities and analyses issues related to energy sources and the market to figure out possible scenarios; the second series of lectures investigates how urban designers and planners can work on the physical layout of the urban form in order to improve the overall sustainability of cities and reduce the environmental footprint of ecological cycles, by improving the efficiency of mobility and energy management (savings and production based on a short energy chain).

For simplicity and due to evident organizational reasons of a one-semester long studio, the design process was structured in three phases: the analysis, the concept-plan with the identification of general eco-strategies and the master-plan with the localized eco-strategies. Of course, we recognize that the process can never be linear, but the given path represented a helpful framework to organize and deliver the different tasks during the studio.

Four themes directed our observations on site and were used as lenses during the whole design process: energy (energy efficiency and renewable energies), environment (environmental quality and comfort, water, waste, permeability), accessibility (sustainable mobility, smart linkage of places, way-finding) and people (place-making, sustainable lifestyle and policies for sustainability). The proposed themes were deliberately broad to encourage an interdisciplinary approach, were interrelated, could overlap and be understood as an opportunity to focus on specific actions that can inform design. In order to guide the exploration and to inform the students about the variety of actions they can implement, the delivery of a “glossary of common terms” was assigned. For instance, each team had to give the definition to a number of terms (actions) and provide a synthetic sheet with description, pictures and references. The glossary was structured according to the four themes introduced above. Once finalized, the glossary was shared among the students and used as a checklist to identify suitable design strategies.

## 4.2. The analysis

In the first step, a deep analysis of existing urban patterns, available cartography, plans and programs (also environmental and energy plans, if any) were investigated to achieve a baseline for the design. In particular, we referred to available cartography and plans from public datasets<sup>5</sup> with the following targets: firstly, to get a comprehensive picture of the programmatic context above the city level in order to verify the compliance of planning options; secondly, to investigate the energy and environmental guidelines established at the regional level, which are necessary for the planning of territorial development policies; thirdly, to manage datasets and spatial information, useful for the territorial understanding of the study areas; finally, the investigation of the environmental framework.

A series of samples extracted from the map were analysed and described, focusing in particular on the shape of the urban fabric and the street network. For instance, a series of clues derived from the shape of those places defined the strengths or weaknesses of the urban tissues and represented the design elements for rethinking more sustainable future scenarios.

A series of maps describing the current situation and conceived as a support for the following design phases was assigned to students as listed below.

- Map 1, Superimposing the case-study area over the centre of the city.
- Map 2, Recognizing patterns (both urban and rural). An interpretation of land use patterns recurring on the territory was asked. Categories had to be provided by identifying morphologies and approximate year of foundation (Figure 1).
- Map 3, The “hard” and the “soft” patterns (Figure 2). The chart gives back an interpretation of those parts of the physical context that can be considered as unchangeable and those parts that might be transformed in the near future. A range of degrees of transformability in between hard and soft can be introduced.
- Map 4, Main land use and soil permeability (Figure 3). This is a map where the three main land uses are indicated: covered areas (buildings) in black, paved open spaces (streets, squares and infrastructures) in grey, and permeable surfaces (green areas, water, non-urbanized areas in general) in white.
- Map 5, Densities on site. Urban morphologies are identified and a qualitative density to macro-areas is assigned, considering groups of blocks.
- Map 6, Street network hierarchy and mobility routes. The existing street network is highlighted and the hierarchy of streets identified. The network of public mobility (train, buses, subways, etc.) is included on the map.

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<sup>5</sup> Main sources used: Piano stralcio per l'Assetto Idrogeologico (PAI); Rapporto sullo stato dell'ambiente in Lombardia 2009-2010; ARPA Lombardia; Rete Ecologica Regionale (approved with DGR n. 8/10962 on 30 December 2009); maps and geo-referenced data from the GEOportale di Regione Lombardia; Piano Territoriale di Coordinamento della Provincia di Milano together with the Valutazione Ambientale Strategica; Piano Territoriale Regionale (PTR) with the Piano Paesaggistico (PPR); Piano Energetico Regionale.

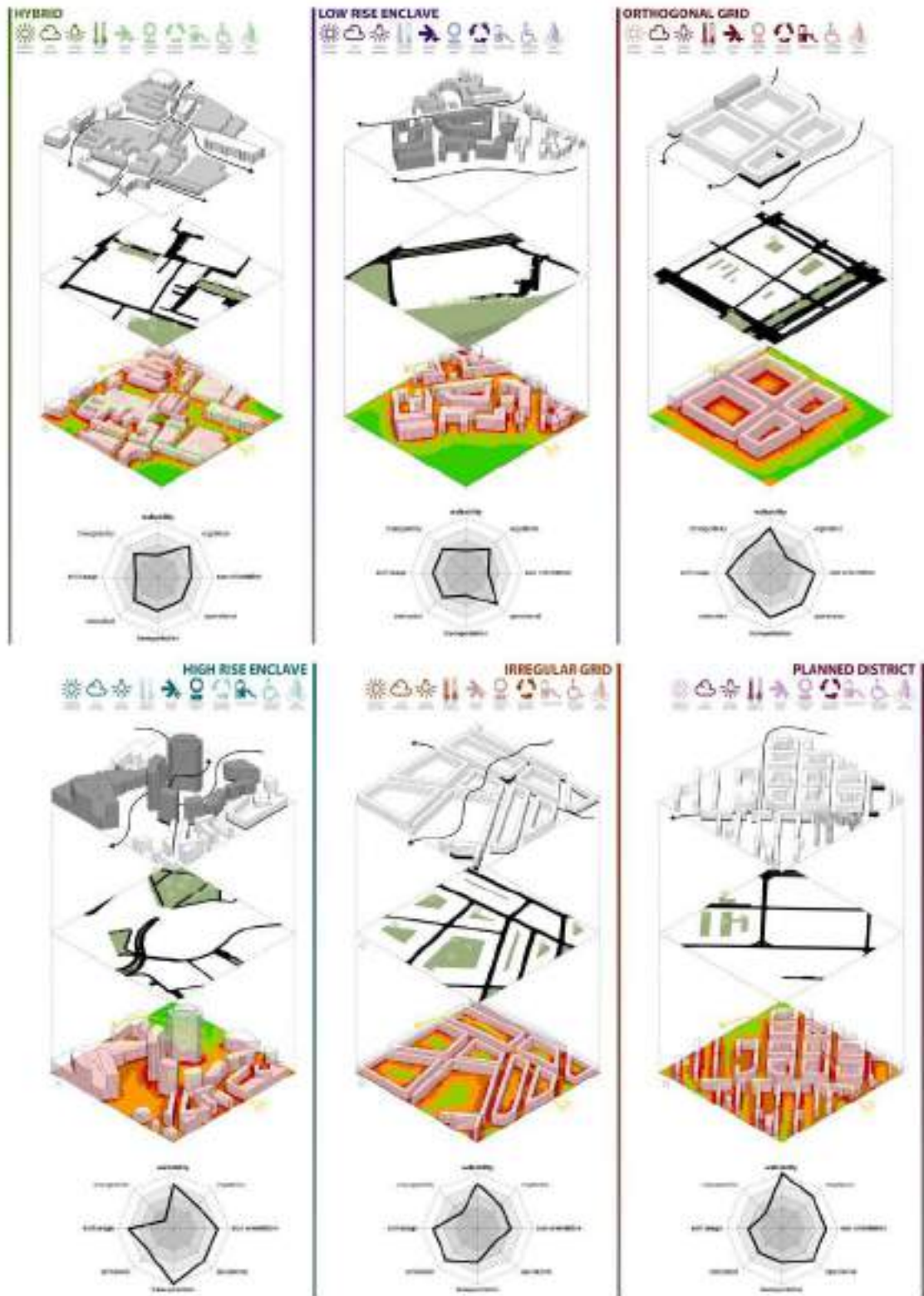


Figure 1. Recognizing urban patterns and investigating urban environmental quality aspects related to the urban form.



Figure 2. The “hard” and the “soft” patterns: the east periphery of Milan where isolated districts coexist with open agricultural land and infrastructures.



Figure 3. Land use permeability samples showing different conditions through the transect from the city centre to the periphery.

- Map 7, The natural green structure. Public and private green areas are defined and urban parks, pocket parks, ecological corridors, big regional parks and similar are identified. Moreover, forests and areas with a high vegetation density, rivers and bodies of water, if any, have to be mapped.
- Map 8, Existing urban services and facilities, both public and private, are identified according to a given set of categories. The main areas and axes of commerce and retail should emerge on this chart.



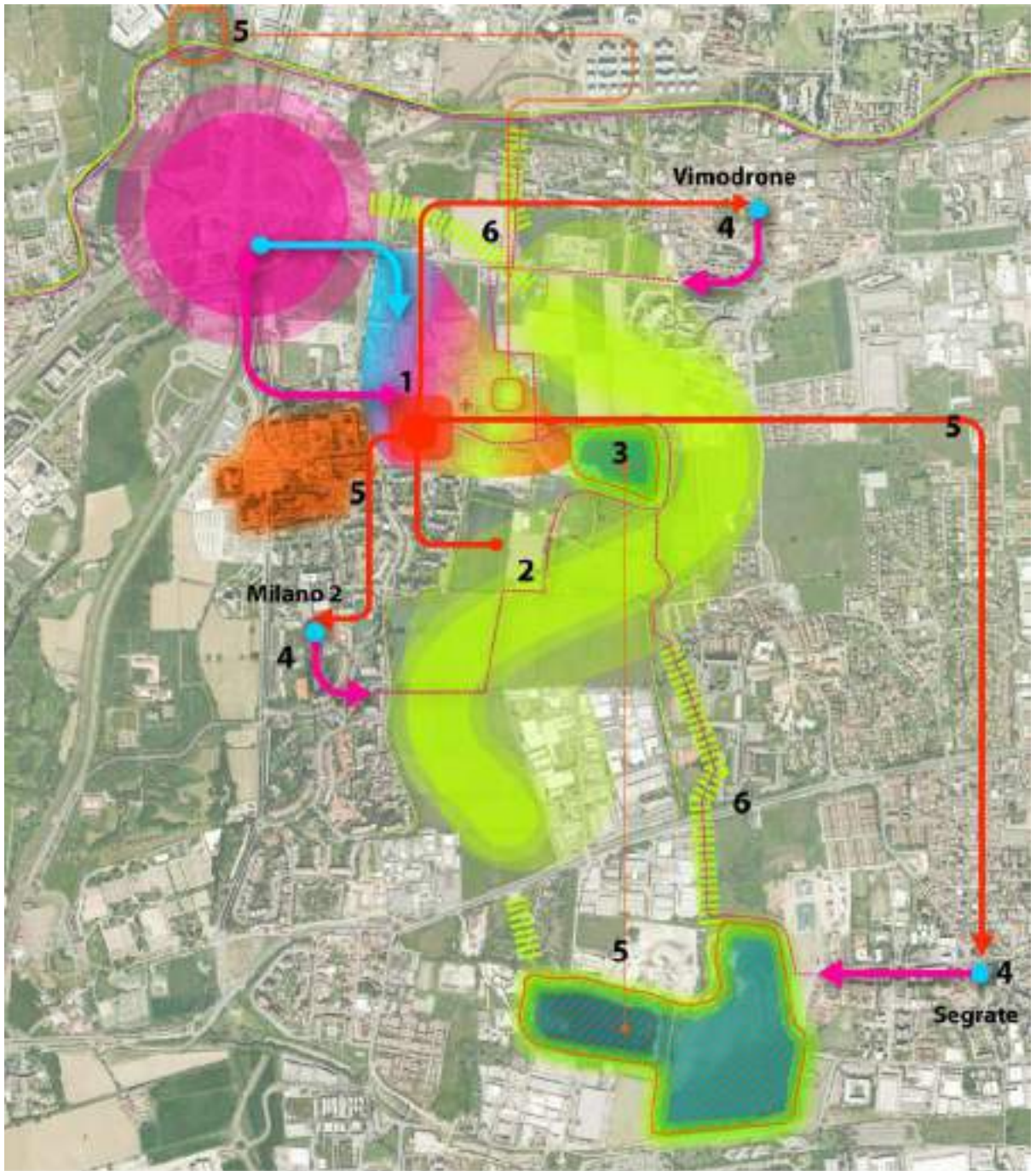


Figure 5. The energy concept-design for the Energy Park in the eastern periphery of Milan: (1) The new energy-oriented centrality; (2) The “Golfo Agricolo”, a green connective tissue with a suburban forest; (3) Quarries, a geothermal source of heat; (4) The existing city with district heating; (5) The improvement of the energy network between the hospital and the other mono-functional districts; (6) Establishment of new green connections.

Moreover, we worked on the implementation and application of simple tools for modelling urban environmental quality (UEQ) and energy indicators in urban planning and design (solar accessibility, connectivity and accessibility, soil permeability). These tools enable to evaluate between alternative scenarios, to verify design schemes and to establish rules for mitigation and compensation. In particular, indicators and maps were used as comparative studies, to assess the changes introduced with the design schemes (before and after intervention). In fact, UEQ indicators are helpful if used as a design tool to evaluate among alternative solutions (Figure 6). For example, the study of the solar accessibility of different urban blocks was used as the basis for the re-invention of a suitable urban block with a higher performance that combines passive architecture needs (solar access on facades) and active architecture requirements (solar access on the roofs for the production of solar energy).

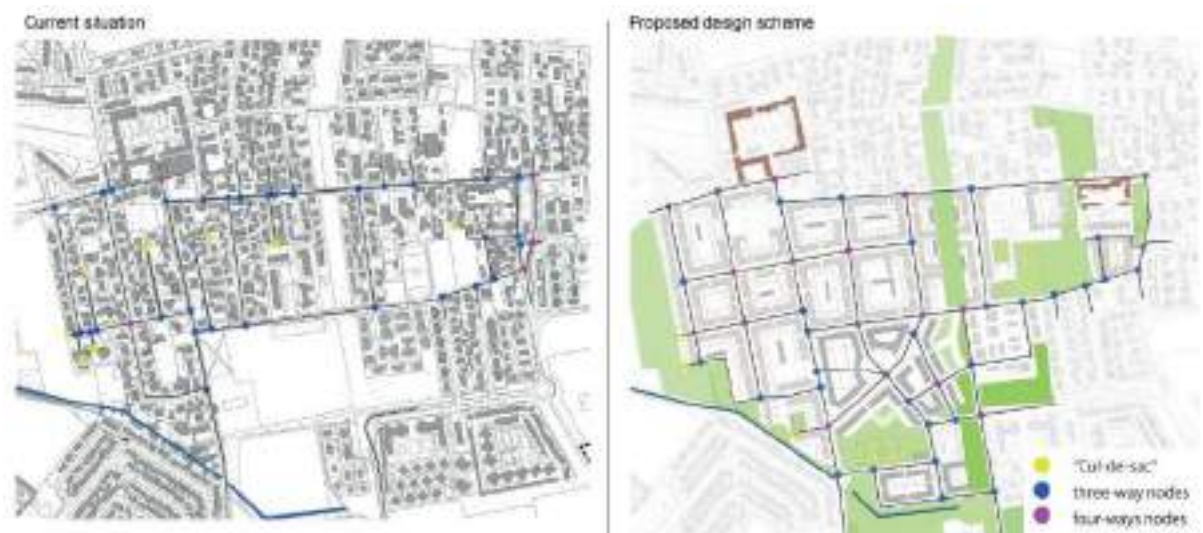


Figure 6. Connectivity analysis of the urban texture: left, the current situation; right, the proposed design scheme improves the overall connectivity by introducing a new central district and reducing the number of cul-de-sacs.

#### 4.4. The master-plan with the eco-actions

The final step was the delivery of the masterplan, which in this case gave back a vision of a possible future for each specific case-study area. In this last insight, the actions related to the four themes (energy, environment, people, accessibility) have been made visible through a spatial localization and sizing, and some clues that an answer to more sustainable urban futures is possible emerged. The vision was supported by the theories and readings, and by the previous phases of the design.

The masterplan consists in a plan (1:2.000 or 1:5.000) on which a meta-design of the built volumes and the street design is clearly visible (Figure 7). For instance, the level of detail goes down to the scale of urban design: the layout of the street with traffic calming solutions, the size and depth of buildings (blocks and plots included).

On that map, the location of the eco-actions is reported and some insights on the proposed solutions attached.

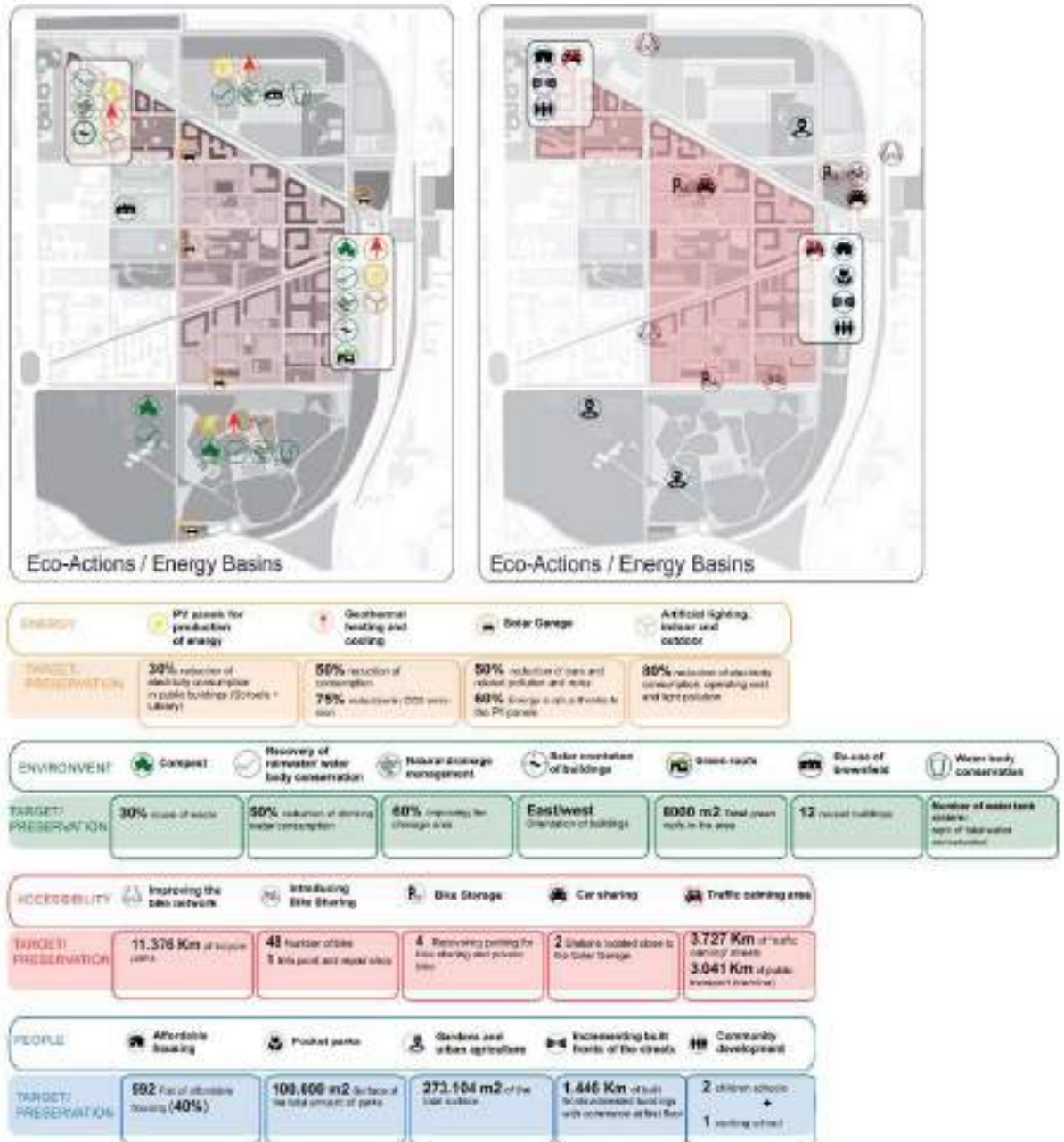


Figure 7. The eco-actions distributed over the masterplan according to the four themes, namely energy, environment, accessibility, people.

## 5. Outcomes

Different samples of the territory show different potentialities in terms of energy savings and clean energy production. The proposed design schemes try to combine urban planning strategies and energy aspects. Beyond the scale of the building where

green technologies are widely used, urban master-planning offers the possibility to scale up energy efficiency if properly taken into account from the initial concept design. A series of design solutions are presented below and analysed through the four themes of the studio (energy, environment, accessibility, people).

### **5.1. The Compact City**

Concerning energy issues, we faced two main areas of investigation for the Compact City: retrofitting the existing urban fabric (buildings) and layout (street network) and proposing new neighbourhoods with carbon-neutral solutions. The idea is to introduce site specific rules and incentives at the scale of the district or even the block. Depending on the age of the buildings, for instance, different policies can be applied. The large stock of buildings from the '50ies and '60ies requires heavier intervention (from insulation of the walls and the replacement of windows, to the redesign of the urban street fronts which is often missing), as opposed to older or more recent buildings. Only after the retrofitting of the building envelope, the remaining energy needs can be satisfied through the installation of solar energy technologies (photovoltaic and solar thermal as in Figure 8) and geothermal solutions. A small cogeneration plant might be an option in the presence of a critical mass of users. District heating is also a solution and already provided in some parts of the city. Hence, the choice of the most suitable technology to achieve the energy self-sufficiency of the built environment depends on the cityscape (in terms of density and shape) and the quantification of different productions is a crucial aspect.

A relevant aspect of the compact city is permeability of the soil and wastewater. The presence of large paved surfaces and roofs was clearly highlighted from the permeability analysis. The existing urban fabric does not have many possibilities to improve the situation, but new neighbourhoods and urban parks are the occasion to adopt the proper infrastructure to separate wastewater on site and reduce the load of the sewerage system. The master-planning phase has to take into account the location and the sizing for street design solutions with innovative drainage solutions.

In both cases, the inner city of a metropolitan area offers a unique occasion for implementing an efficient sustainable mobility. For instance, public transport and bike lanes represent the basic solution to achieve energy savings in transport; further strategies like car-free neighbourhoods, car-sharing and policies for the introduction of private electric vehicles (dedicated parking areas and solar garages) were proposed. Again, all the mobility strategies have to establish a strong link to the physical design of spaces: in fact, without a proper design of both the street network (in terms of hierarchies of paths) and the built form (distribution of densities and land use along transportation nodes), mobility strategies might fail. Moreover, the proposed analysis on accessibility had the aim of improving pedestrian movements on the territory by providing more paths and hence a larger catchment area (the so called ped-shed). Creating pedestrian friendly environments is not just a matter of quantity but also quality: traffic calming solutions, attractive fronts and the presence of services are key factors for successful streets. All the buildings have to be

reachable within a five minutes' walk in order to avoid the use of private vehicles and enable the introduction of car-free districts.

The city is the best place to trigger behavioural change and to gather people with common interests. A dedicated program for a solar community that shares the diffused renewable energy produced on site, the introduction of a series of initiatives for improving a sustainable lifestyle (bio-market, sharing of facilities and co-housing), mixed uses and diversification of population are only few samples. In fact, the paradigm of *mixité* has also energy implications: the coexistence of different typologies of citizens and urban functions means different lifestyles and energy peaks in time. A smart mix of energy uses can lead to site-specific policies aimed at smoothing peaks.



Figure 8. The analysis of the solar potential on new roofs: above, the quantification of available roofs, and below, the suitable areas to be connected in a closed network.

## 5.2. The Edge City

The periphery of the city offers the most diversified catalogue of land- and cityscapes. The presence of large areas susceptible to transformation, the balanced mix of built spaces and natural environments (mostly residual green areas) represent the most intriguing challenges for future city scenarios. In that physical context, the application of urban ecology strategies is possible and desirable. For instance, the presence of a pond obtained from a quarry is the occasion to exploit the temperature of the water body to produce energy through heat pumps that can be activated through electric energy generated from photovoltaic modules installed on roofs (Figure 9). In another case-study area the rich agriculture and farm production close to the city can provide biogas and biomass for a small local plant (Figure 10).

Large natural areas can be converted into parks or preserve the agricultural function, if any. Those parks can represent the showcase to implement sustainable agriculture

or biomass plantations (short rotation forestry). Sustainable strategies for water management can be implemented as well.

Concerning accessibility issues the edge city is the place where interchange of transport systems happens. Investigating new solutions for the design or interchange nodes will improve sustainable mobility. Innovative solar garages for commuters with dedicated solutions to encourage the use (and ownership) of electric vehicles in the city and car sharing programs can drive a significant change in the urban mobility. From an urban planning perspective, the edge city was mostly built as a juxtaposition of segregated functions with little interconnections among each other. In fact, the proposed concept-plans aim at establishing new hierarchies and legibility among closed districts.

In terms of social strategies, the general aim on the sprawl city is to provide a stronger urban character to places, thus reducing the need to move to the city and creating a stronger sense of belonging: mixed use, mixed densities, social mix, environmental diversity, access to abundant natural areas, transit oriented districts are the key actions to be implemented.

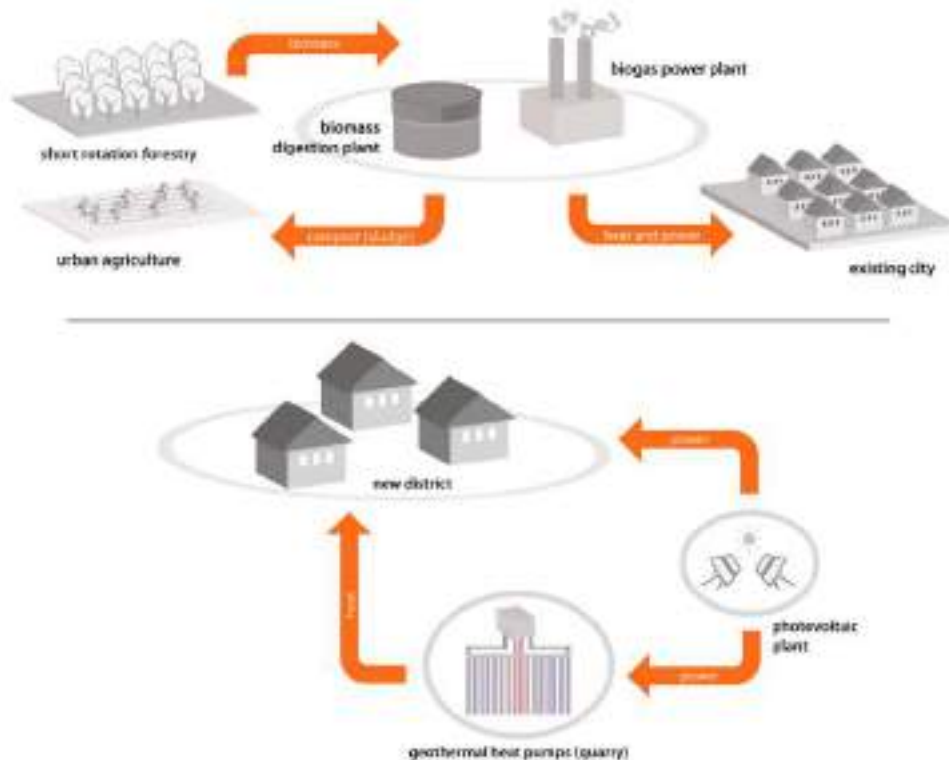


Figure 9. Energy cycles on site: above, the introduction of a biomass cycle with a short rotation forestry plantation in the park and the installation of a biomass digestion plant to produce compost for urban agriculture, plus a biogas power plant to provide heat and power to the existing urban fabric. For the new district (below) geothermal heat pumps work with the water of the flooded quarry. PV panels on roofs provide the power for the pumps that generate heat and cool for the buildings.

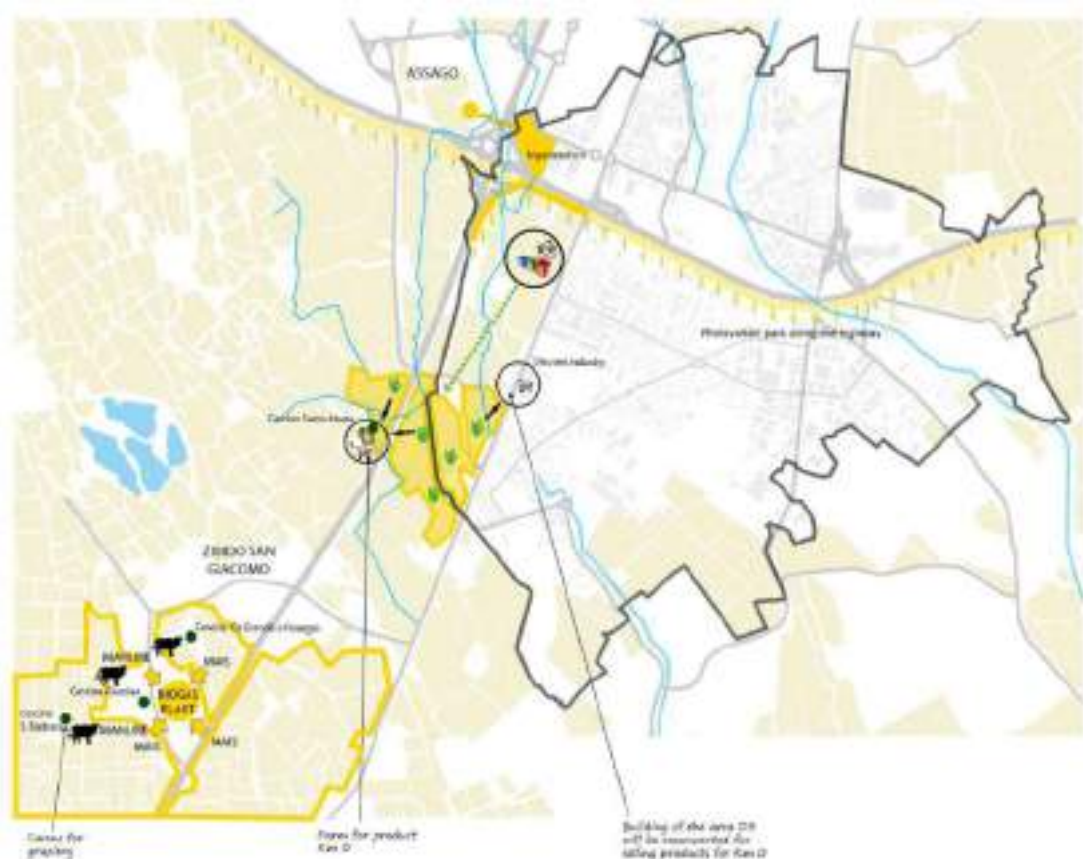


Figure 10. The renewable energy framework aims at reaching a self-sufficient production for the new development. For instance, agriculture and farm production provide useful material for a small biogas plant to be installed on site and serve existing neighbourhoods. The energy for the new district will be provided by a trigeneration plant and the installation of a linear PV park along the highway.

### 5.3. The Diffused City

A low-density city form encourages to look for energy solutions at the small scale. For instance, the carbon neutral building equipped with eco-technologies is the easiest strategy to pursue in the absence of more effective urban planning solutions, like urban infilling (densification of the urban form as proposed in Figure 11). In the northern part of the metropolitan region, the diffusion of industry represents an occasion for the replacement of part of the production with more sustainable retrofitting strategies (using roofs for solar energy production or green roof technologies for drainage and thermal mitigation of the urban environment). For instance, the role of industry should be converted from energy consumer to energy producer. In particular, the deep interrelation between household and industry on this territory can be intended as a resource in terms of mixité, thus it might be convenient not replacing industry with residential areas but with other forms of production (clean energy) and workplaces (services and tertiary). Another key-element on the territory is the presence of large transport infrastructures that cross and divide places.

Railways and motorways together with the residual spaces they create could be reinvented as energy conducts, thus having a positive feedback on the territory (Thün & Velikov, 2009).

Environmental actions aim at improving and increasing the open space and green structure by insisting on ecological connections and wooded areas (re-composition of natural patterns). This supports the maintenance of a high degree of permeability of the soil to be complemented by the development of a system for the rainwater management, which requires a strong link to the physical master-planning of places. Moreover, weak residual agricultural areas could be converted for local production by introducing dedicated policies.

Accessibility remains the big issue of the sprawl city. Promoting the polycentric city with transit oriented developments matches the most popular urban design approach. Nevertheless, that strategy had scarce success in the recent past, if we consider the vast use of the private car and the economic costs to sustain an efficient public transport in these low-density territories. The diffusion of electric private vehicles could be a solution if scaled up and supported by clean energy. For sure, a crucial option is to work on the improvement of the street connectivity and design, therefore ensuring a better access for pedestrians.

The actions related to people comprise the creation of areas in which promoting social practices. For instance, the reuse of industrial areas for new activities (also directly related to energy production) and the creation of new centralities (district centres with services and mixed uses) in order to improve the identity of places (place making strategy) are the principal solutions to be explored.

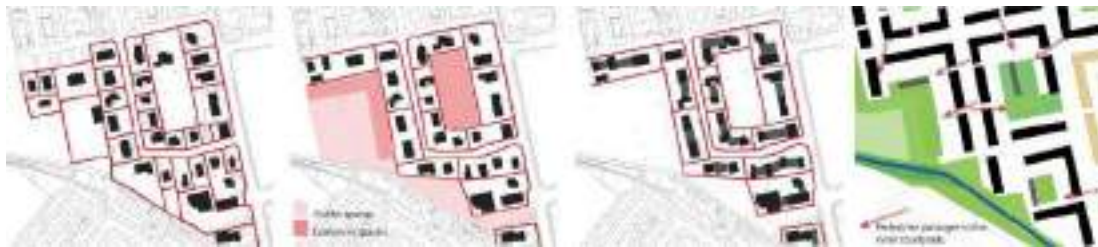


Figure 11. A long term strategy: from the current block fragmentation (1), through a process of property matching and increase of public and common spaces (2) and consequent densification (3), to the reconstruction of urban courtyards (4).

## 6. Conclusion and future work

Outcomes of the studio show that the contribution of urban planners to sustainability implications of the territory can be relevant. In fact, anticipating energy strategies during the master-planning phase is crucial, because the physical layout of both the urban fabric and the street network have an unquestionable importance in assessing energy consumption. The results of the studio show that not only technology can give an answer to sustainability, but also the configuration of the physical space, in particular the relation between land use, urban density distribution and street

hierarchies. Promoting proximity through a proper urban design with high quality is the first action in order to achieve reduced energy cycles on the territory.

Moreover, the scale of action, i.e. the small town or the neighbourhood reveals to be a proper dimension in order to apply simple strategies of urban ecology. Action-plans promoted by numerous European cities represent a general framework of strategies, but do not have a strong link to the different urban configurations (and hence to the different energy potentials). On the contrary, we focused on the implications of the built environment in assessing sustainable actions.

The relevance of the work to planning education will be enquired, in particular how considerations on energy and environmental quality can affect the design process and the physical layout of the final scheme.

For the second edition of the studio, a series of improvements are under investigation, also according to students' feedback. Of course, the limited time-budget of the studio (one semester-long class, which means about 14 full days of workshops) is an issue: for instance, introducing new activities will happen at the expense of others.

For sure, the quantification of energy savings will be explored with a deeper insight during the class, because students have shown to be interested in getting more validations and quantifications about their design schemes and energy scenarios. For instance, assessing the reduction of CO<sub>2</sub> emissions with easy calculation methods in order to compare alternative design solutions is fundamental, in order to offer a draft measurement and evaluation of concept design solutions. The SEAP experience with the Baseline Emission Inventory (The Covenant of Mayors Office, 2008) might represent a good starting point.

Moreover, we would like to improve the quality and quantity of the data to be used for the guiding the design and building the energy scenarios. Data acquisition was always a big hurdle, even if students in urban planning are quite trained in searching for data and cartography, especially from public geo-portals. Nevertheless, the aim of the studio was not to spend too much time in collecting and organizing detailed data, but rather to work on hypotheses based on the estimation of energy demands and energy production on the territory, even with limited data and resources.

Finally, beside the delivery of theoretical knowledge through lectures and readings and the glossary of common terms prepared by the students, a systemized investigation of best practices will be explored. For instance, the application of innovative clean technologies at the large scale or the introduction of successful policies can be collected and shared among the students as a reference for their design projects.

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