Sustainable solutions in architecture:
their integration and impact on contemporary collective housing.

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-discussion of the SIA 112/1 Recommendation as an introduction to the residential project in the ecodistrict of Plaines-du-Loup, Lausanne.

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Foreword

I wish to devote the final work of my studies to the points of particular interest gathered through the years of academic education. Their common feature and goal is to contribute to my competence as of future practising architect- therefore they are all rooted to the bare reality and its ever increasing technological requirements. These often put to the test any initial architectural intentions and concepts. Those latter are inevitably confronted with the growing number of specialized branches participating in the project and one may notice that architect's supremacy is losing its importance. Or, acquiring a multidisciplinary knowledge might facilitate his collaboration with numerous experts and result in better control over the project, which is my personal aim. Therefore my final academic task is taken as an opportunity to:

- familiarize with the widely emerging requirements concerning the vast theme of sustainability
- extend the knowledge of the related building technology solutions,

both of which are decisive for conscious shaping of contemporary architecture. On the verge of professional career, I wish to interiorise this knowledge, which should prove useful regardless of the future place of practice, as more and more countries actively engage into environmentally conscious action.

Goals

With this work I principally wish to clarify my understanding of the vast problematic of sustainability within the Swiss context, as well as to utter own opinion towards it. As the phenomenon is undeniably gaining in importance, and the confrontation with its aspects becomes unavoidable, this paper is to introduce me to the broad thematic.

Secondly and more precisely, I aim to get through the SIA 112/1 recommendations, which categorize the multitude of aspects of sustainability. To improve my understanding I want to discuss the recommendations and see their application in real life. The document's exhaustive character provokes a hypothesis that it is merely impossible to satisfy all of them in the single work of architecture, due to their ample scope.

Therefore the third goal is to detect conflicts and synergies induced by the recommendations, and find out how can they be reconciliated in reality. Having noticed these interactions between the different branches, I wish to examine the complexity of relevant solutions. For example, one of the clearest illustrations of conflictual relationship is the treatment of the solar radiation. On the one hand it is an excellent source, while on the other may result in overheating. Similar examples are numerous, and the final configuration of the solutions is revealed in the case studies.

The fourth goal is providing a base for a later project, which is a fixed application of the chosen technologies. The beforementioned example of valorising the solar energy is a major premise for the diploma in which I will elaborate a precise configuration of solutions to benefit maximally from the local climate and urban position. More than that, the fields related to social and economical issues shall not be neglected, as they also largely contribute to the sustainable development.

As much as the abstract recommendations, the site requirements apply as well. It is the fifth goal: to familiarize with the project's localisation and its particularities. The ecodistrict of Plaines-du-Loup is in the most advanced stage of planning compared four other future neighbourhoods of Lausanne. Furthermore, it is aiming to be compatible with 2000W Society concept, so the set its own recommendations has been issued, which will be studied in order to see how could they affect the later project.

Methods

The recommendations are summarized following the SIA 112/1 table of contents. They are illustrated by relevant solutions from the pool of Swiss collective housing projects in order to examine their applicability. Since it is impossible to address all the fields in equal measure, the particular stress will be put on the environment part, that is the most quantifiable. Secondly, the social and finally the economical issues will be considered as they form integral part of the sustainable approach.

Once an extensive study is done, the comparisons and interactions between different fields are noticeable and will be evidenced in the summary chapter. This will be the first input to the later project. Regarding the analytic part of the Plaines-du-Loup, the official documents concerning the site will be examined. The summary of the requirements will be provided, in order to see how do they influence the project. The two-part work is terminated with a chapter of final remarks.

The nature of the sustainable development criteria

The “Recommandation 112/1” is a set of guidelines issued by SIA, intended as a medium between the contractor and the designer. The document’s methodical character and clear organization successively enumerates the areas contributing to the buildings’ sustainability. The review in the form of the table serves as a clear base to establish the key points of focus in the project, clear for all the parties and specializations involved.

The document itself has no legal force, but taken the growing interest towards environment protection, the Recommendation might evolve into a legal norm. At present, the obligation towards sustainability stems primarily from the Swiss constitution where it was introduced in 1998. Also, the Federal Office for Spatial Development ARE is coordinating the implementation of the sustainable development on three administrative levels: federal, cantonal and communal; all according to the Sustainable Development Strategy. The local level (cantons and communes) play a key role in this process, with their own strategies based on Agenda 21[1] largely influencing the legislation. Therefore the cantons, which handle their own construction and energy laws, start to set target higher than the current norms (for instance, the Canton of

[1] the plan of action of 1992 UN Conference on Environment and Development.

Geneva imposes the high energetic quality standard upon all new construction)[2]. Furthermore, the communes tend to engage themselves in even more strict action, declaring realisation of exemplary projects e.g. Plaines-de-Loup ecodistrict, that complies with 2000W Society strategy.

Apart from legal constraints, the phenomenon of energy certification has widely spread not only across the Switzerland, but also through most of the Western world. The expansion of Minergie standard is particularly interesting, given its voluntary aspect. It is acquiring an economical dimension and becomes an object of desire within the more and more conscious society. The established values and methods are widely recognized; not only are they used in Italy, Austria and Liechtenstein, but also serve as a benchmark for the local legislation[3]. This is putting Switzerland in the position of the pioneer in terms of care for environment. According to Kuznetsov cycle concept, this country has long ago abandoned the stage of *poor and dirty*, and through the *rich and dirty*, has finally reached the *rich and clean* position[4]. The role of the leader results in research and experiences that are being exported. Even though many of the developing countries are consuming less energy per capita than the first world, their footprint is larger in terms of emissions. Interestingly, the implementation of the environment-friendly measures to improve this state does not necessarily mean tight economies- instead, it promotes the solutions which do not compromise the quality of life. They sustain it by gentler means, thus the related know-how should become more and more globally desired.

Apart from the Swiss systems of certification it is worth noting that there exist several parallel criterions and sustainability policies in different countries (e.g. HQE in France, LEED in United States or BREEAM in United Kingdom). Each slightly differs in assigning the weights to certain factors. Moreover, the particular sets of indicators were tailored for the most emblematic projects like Vauban (Freiburg Brsg.) or Malmo Bo01. These pioneer realisations and their characteristics still serve as a point of reference for the construction of the new ecodistricts- and so happened in case of Plaines-du-Loup.

[2] Législation genevoise, Loi sur l'énergie (LEn) L 2 30, Art. 15
[3] Législation genevoise, Règlement d'application de la loi sur l'énergie (REn) L 2 30.01, Art. 12B, al. 1
[4] Hegger, Manfred. *Energy Manual: Sustainable Architecture*. Basel: Birkhäuser, 2008, p.26

Although evaluating sustainability on an international scale is not always unambiguous, the effort of monitoring and quantifying is nevertheless maintained in order to:

- constantly improve the common knowledge
- facilitate the comparisons (benchmarking)
- spread the good practice

According to sustainable development ideals the three mains fields should not develop to the detriment of each other[5]:

- society
- economy
- environment

hence the balanced aspect of growth. Architecture is the discipline fully interfering with the three issues, which is reflected by the structure of “Recommandation SIA 112/1”. It will be discussed on the basis of the recent Swiss housing projects. The pool contains mostly the Swiss-german realisations, which became naturally the starting point of this work. It is due to the long-lasting traditions of care towards the environment as well as to the fact that prevailing part of Swiss urban development took place in the northern part of the country. With the relatively recent rise of of the Lemanic Arc phenomenon, the Romandy took the opportunity to invest into the state-of-the-art technologies; therefore the list is completed with its contemporary examples. Judging by Minergie standards, the canton of Ticino, representing the italian-speaking part, has the smallest number of the certified buildings.

[5] as stated during Rio summit in 1992

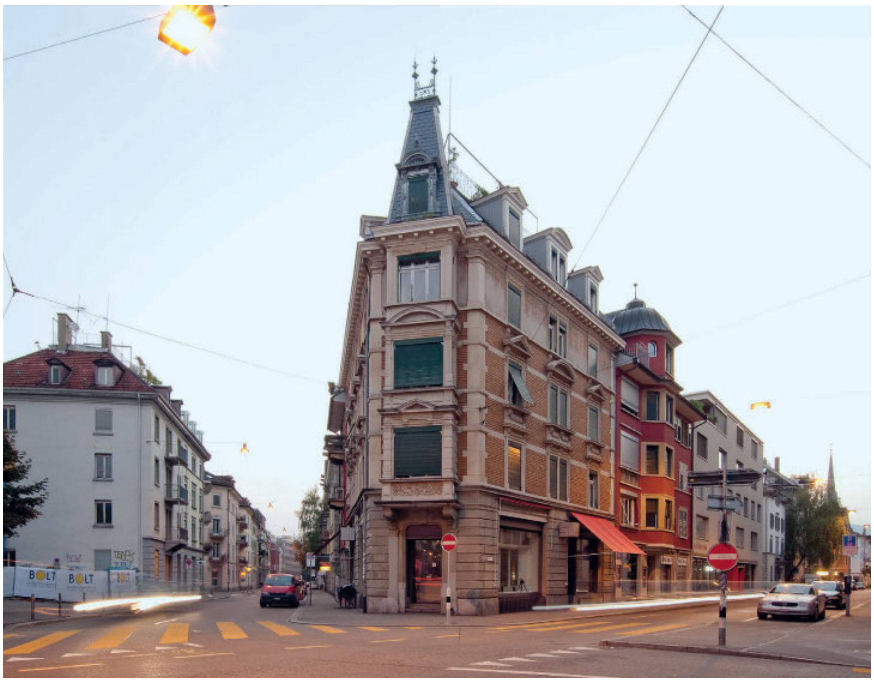
The cases which are the richest in interesting solutions -and thus most often referred to- are illustrated on the following pages as a visual introduction:

- Cressy, Onex/Confignon (GE), Atba bureau d'architectes
- Das Dreieck, Zurich, Fahrländer + Fries Architekten
- Eikenott Ecoquartier, Gland (VD), multiple authors
- Hegianwandweg, Zurich, EM2N
- Kloster Wesemlin, Luzern, Lengacher Emmenegger Architekten
- Kraftwerk 1, Zurich, Stücheli and Bünzli & Courvoisier
- Rue Sonnex 36 (Pommier A, B1 and B2), Grand-Saconnex (GE), authors respectively: GM Architectes Associés, De Giovannini SA
- Sihlbogen, Zurich-Leimbach, Dachtler Partner Architekten
- Vallée de Jeunesse, Lausanne, Farra & Zoumboulakis architectes
- Victor-Ruffy, Lausanne, Bonhôte Zapata Architectes

Since their features do not fully exhaust the spectrum of discussed guidelines, therefore secondary examples appear in the course of text, mainly to explain the particular aspects. When needed, an extended case study is introduced to depict the complexity of the applied systems, hence the auxiliary pool:

- Am Rebgässli, Allschwil (BL), Amrein & Giger
- Casa Montarina, Lugano, architect: Lorenzo Felder
- Eichgut, Winterthur, Baumschlager & Eberle
- Eulachhof, Winterthur, Schwarz Architekten
- Fehlmann Site, Winterthur, Bob Gysin + Partner BGP Architekten
- Hagenbuchrain, Zurich, Bünzli & Courvoisier
- Kraftwerk B, Bennau (SZ), Grab Architekten
- Multifamily dwelling, Dübendorf (ZH), Beat Kämpfen

1. Cressy, Onex/Confignon (GE), Atba bureau d'architectes



2. Das Dreieck, Zurich, Fahrländer + Fries Architekten

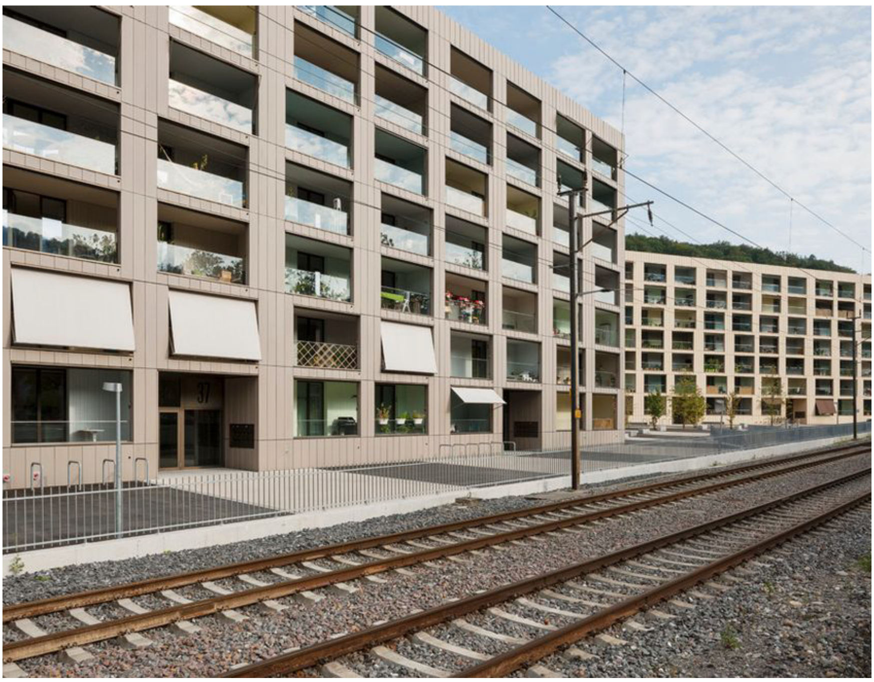
3. Eikenott Ecoquartier, Gland (VD), multiple authors

4. Hegianwandweg, Zurich, EM2N

5. Kloster Wesemlin, Luzern, Lengacher Emmenegger Architekten

6. Kraftwerk 1, Zurich, Stücheli and Bünzli & Courvoisier

7. Rue Sonnex 36, Grand-Saconnex (GE), multiple authors



8. Sihlbogen, Zurich-Leimbach, Dachtler Partner Architekten

9. Vallée de Jeunesse, Lausanne, Farra & Zoumboulakis architectes

10. Victor-Ruffy, Lausanne, Bonhôte Zapata Architectes

The critical review

Due to the broad scope of the theme, the presented work will focus mostly on the environment part, as it is more stable ground for the project, as well as personal interest. Environmental analysis depends less on imprevisible factors, than does society or economy; thus it can be analysed with a good approximation. The number of related solutions is large hence this written work is to synthesize the knowledge and narrow down the choice for the final project. The criteria are listed according to their original position in the 112/1 Recommendation, which is included in the end annex. Principally, the composition of the document is three-part, divided in:

1. Domains

1.1. Chapters

1.1.1. Subchapters

This structure is preserved in the following work. For the quick identification, the numbering corresponds with the original, as well as the french title is provided in brackets. The three major domains are treated in the following order: Society-Economy-Environment, so that the first two ones introduce and enable better understanding of the final part.

1. Society

The list of the indicators is opened by the social area although in the common belief, the term of sustainability is assigned almost exclusively to the domain of the environment. This chapter takes into account the following factors:

- living together
- equipment
- exploitation and viability
- comfort and health

The first two ones are based upon judging a rather subjective feeling, thus difficult to evaluate and anticipate at the stage of design. On the contrary, the former two are more scientific-based and thus quantifiable; they are also more often treated in the projects descriptions.

1.1. Living together (vie en commun)

This chapter is based on conviction that the districts of functional diversity prove to be more stable environments with bigger aptitude towards the change. Ideally, they shall also prevent social, ethnic, and demographic dislocation. Their design should facilitate the social meetings, as well as provide house for those with less purchasing power. Finally, an important postulate is to involve the future tenants into planning process, in order to facilitate later domestication of the new habitat.

1.1.1. Integration and coexistence (intégration, mixité)

The exemplary project addressing the social mixity is The Dreieck in Zurich, a partial renovation and infill within a late nineteenth century triangular quarter. The name does not only describe an urban figure, but also a tight community of its inhabitants, who has commenced the renovation as a bottom-up initiative. The neighbourhood reflects the idea of mixity par excellence in respect to:

-different social, ethnic and financial status of inhabitants
-functions available in the neighbourhood
-completing the old development with new intervention and renovation

The openness towards the mixity is also clearly manifested in the charter issued by the Kraftwerk 1, that preserves the shared values, like maintaining the availability towards the new inhabitants, regardless of their sex or origin[6].

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[6] *Possible Urban Worlds: Urban Strategies at the End of the 20th Century*. Basel: Birkhäuser, 1998. Print. p.56

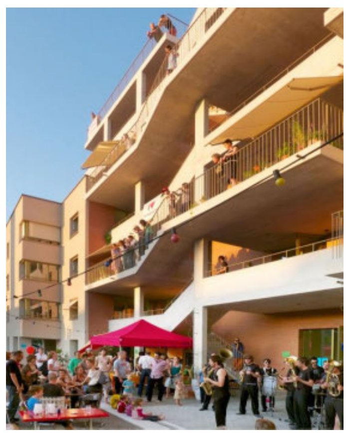
The Kraftwerk 1, apart from its architectural qualities can be considered as large social bottom-up project; which is rarely the case in majority of modern housing development.

The tool to provide the maximum mixity without preexisting association of inhabitants is offering the multitude of the apartments typologies, as in case of Eikenott district in Gland. A wide choice varies from 1.5 to 5.5 rooms flats. Also the different modes of occupation and financing are possible thanks to subventions, rented and for-sale units.

1.1.2. Social contacts (contacts sociaux)

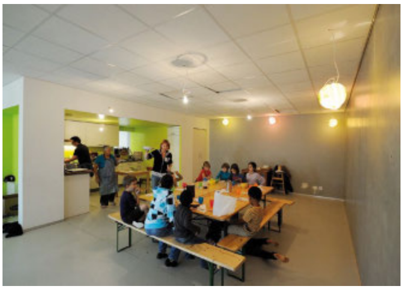
The most illustrative cases of space adapted for the social contact are those which were constructed from the initiative of future inhabitants. In terms of common space of social meeting, The Dreieck is a model solution. The courtyard is clearly enclosed by the buildings, but well accessible and permeable for the pedestrians, given the number of venues and related events taking place there. The choice of ground floor commercial tenants is made according to the proposed activity, not the highest rent offer. The social contact was a highly prioritized value, due to the fact that inhabitants were their own clients.

11.Dreieck



12. Kraftwerk 1

Analogically, Kraftwerk 1 possessed a group of motivated tenants, apt for the typological experimentation, which led to creation of communicating balconies, the shared “wash-salon”, or an almost extreme typology of the 15 rooms flat with the common living room. The social contacts are also facilitated thanks to local shops or collectively-ran daycare center. In Romandy, though in the smaller scale, the cooperative Equilibre from Cressy (Confignon, GE) is particularly active, having already constructed its first house, that also offers generous communicating balconies, car-sharing system and common allotment garden.



13. Pommier A

14. Cressy

Finally, even in the architecture without the predefined occupant, the shared areas are being foreseen. For instance, the Pommier A building (Grand-Saconnex, GE), despite its regular single corridor typology, offers the shared multifunctional rooms, which challenge the individual-cell mode of occupation and life.

1.1.3. Solidarity and equality (solidarité, justice sociale)

As far as social solidarity is concerned, the aim is to provide space affordable for people with various social background. As already mentioned, it can be realized through the diversity of typologies. It is also noteworthy, that in case of Dreieck the contractor offered the job for the unemployed members of the community at their own construction site. It is an evidence of profound understanding of principles of constructive solidarity-a true sense of the cooperative. Within the Kraftwerk 1 neighbourhood, many of the ground floor services are ran by the inhabitants. Apart from the commercial activity, the local exchange trading services (LETS) are particularly interesting as they enhance the contacts between the neighbours. The community has also established a common fund intended to correct financial disparities. All these factors prove that life within a community has an important participative aspect.

1.1.4. Participation (participation)

Encouraging the participation may take various forms and in case of cooperatives comes naturally. Otherwise it might be realised through the discussions and consultations with future inhabitants. For example, the Hegianwandweg housing was tailored to the specific needs: the tenants could have chosen from the catalogue of solutions designed by the architect[7]. It resulted in a multitude of possible appartment arrangements: ultimately 60 out of 75 units have unique layouts. Looking at the urban scale, the high degree of participation may in some cases lead to conflicts with the factors, that are later described, e.g. the arising need of densification of the downtowns (see the chapter 2.1.1 Site). As shows the Lausanne's referendum upon the Taoua Tower, as well as protests in Montétan, the densification is not always feasible[8]. The idea of growth with quality is very strong, opposedly to the action focused on the short time profit.

1.2. Equipment (aménagement)

This chapter is treating the theme identity with the sense of belonging to the place and its aptitude towards personalization. It is a challenge especially in regard to the new housing developments, which often miss a *genius loci*, or the patina acquired with time and gradual settling of the inhabitants. The bonds and common recognition of a new place arises relatively slowly and according to subjective patterns. Despite it is hardly predictable in detail how will the people relate to the common spaces, there exist means to encourage such domestication.

1.2.1. Identity, sense of belonging (identité au lieu, appartenance)

Factors of successful common space are hardly quantifiable due to their extremely subjective nature. In this regard, the renovation has certain advantage over entirely new developments, as it can be observed in case of Dreieck, which did not lose its vital momentum during the transformation period. The inhabitants were strongly engaged into planning with the architects. The resulting atmosphere seems to have achieved enormous added value, since the relax and social interaction expression is possible in their closest vicinity. This conclusion is valid for any project initiated by the

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[7] Strumillo, Jan. Economic Backbone of Swiss Sustainable Housing: Case Studies. Zürich: ETH, 2008, p. 109

[8] Dessemontet, Pierre. www.hebdo.ch/les-blogs/

cooperatives, since the personal bond between project and inhabitant is inherent.

1.2.2. Customization (aménagement individuels, personnalisation)

The man needs the points of reference in order to familiarize and orient himself in the new settlement. A particular attention should be made to avoid the anonymous character of the neighbourhoods. Since the large projects are often delegated to different architecture offices, it results in variety of design expression that is considered an advantage. Concerning the Plaines-du-Loup, this diversity is almost as important as the energetic requirements, for it might equally affect the quality of human life. The exterior spaces are also crucial in this regard, however their dimension should not enter in competition with the economy of the land. Moreover, many of the contemporary housing settlements are equipped with *Kunst am Bau*, that is an artistic decoration, whose budget is secured in advance.

15. Hegianwandweg, *Kunst am Bau*

16.Sihlbogen, passage to train station

1.3. Exploitation and viability (exploitation, viabilisation)

This chapter is dealing with rich functional composition, shortening necessary distances and accessibility in the broad sense. Those notions are more adequate towards the scale of the whole neighbourhoods, than singular buildings.

1.3.1. Supplies proximity (proximité d'approvisionement)

It postulates the diversity of functions and their proximity, in order to reduce the daily commuting. This subchapter speaks exclusively of short distances on the local district scale; the long ones are treated treated in the subchapter

3.4.1. Mobility. As the transport contributes to 20% of todays 6400W consumed by an average Swiss[9], this branch is comparable to the needs of heating and presents potential for economy. In order to reduce the commuting, the mixed-use project shall be favored, as they might provide majority of daily services within a walking distance. The ancient principle of functional zoning of the city is gradually replaced by the more independent and well-equipped smaller-scale neighbourhoods. The Eikenott serves a good example, as it comprises a retail store, pharmacy, the vegetable market as well as a kindergarten within its perimeter.

1.3.2. Light mobility (mobilité douce)

The light mobility takes into consideration the means of transport of low carbon footprint, like:
-bikes (private, public, also electric)
-walking
-public transport

In order to render them attractive a considerable infrastructure must be implemented, apart from bare access points. The three aforementioned means are progressively working as one coherent network- it is nowadays a rare case to use only one mean of transport on a single journey; the commuting pattern became complex. Therefore the location of the stops, bike deposits and pedestrian paths must be immediately identifiable in order to convince the potential user. The covered sidewalks should be offered in maximum possible extent to encourage the pedestrian movement. Ideally, the walking itself, should be considered as more of experience, than simple covering of distance. Lastly, the car-sharing which is also considered as mean of light mobility, is discussed in the subchapter 3.4.1 Mobility.

1.3.3. Accessibility (accesibilité et utilisabilité par tous)

The notion of accessibility should be understood in a broad sense. Its features, usually attributed to the handicapped, prove helpful in case of exceptional situations (temporary disability, cumbersome luggage or a pram). Their application evidently collides with the economy of the space, and is usually reduced to the selected apartments. This approach has not been

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[9] Preisig, Hansruedi, and Katrin Pfäffli. *Objectifs de performance énergétique SIA - Un projet de Swiss Energycodes le la KHE/SIA*. Zurich: Société Suisse Des Ingénieurs Et Des Architectes, 2006, p.32

whatsoever addressed in any of the presented projects, apart from providing the quota of apartments adapted for the handicapped.

1.4. Health and comfort (confort, santé)

It is the introduction to the set of subchapters, which revolve around the sentiment of human comfort. The belonging criteria are very often addressed in the analysed projects due their technical support. Almost all of the following factors contribute to the interior environment quality, and depend solely on building technology. In particular, the sun-related issues form the central part of this work and will return in the later chapter 3. Environment.

1.4.1. Security (securité)

This point touches on security in its multiple aspects: that of criminality, of natural hazard, and of personal accidents; in either case their prevention largely contributes to social and economic stability. Thus the exterior spaces should primarily be animated in the daytime, allowing the natural social surveillance by multitude of visual links. In the nighttime, the proper lighting is indispensable although it contributes to large part of electricity consumption. There exist however systems of voltage-lowering, which coupled with movement detectors, allow economies of the order of 30%.[10]
The security from accidents is a standard measure regulated by respective SIA norms and is assured by means of e.g. railings, non-slip surfaces and contrast signs on the pavements. Finally, the major natural-hazard that potentially affects the Swiss housing architecture is the seismic activity. The anti-seismic protection is an obligation in Switzerland since 1989, and in case of collective housing, often takes form of continuous reinforced-concrete wall. As an autonomous and *a priori* uninterrupted element it might affect the flexibility of the floorplans, if not foreseen from the early stage. This poses threat to the possibility of posterior rearrangement. On the other hand, when skillfully integrated, the anti-seismic wall presents great potential of thermal mass, which is discussed in chapter 3.2.1. Heating and cooling.

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[10] *Projet Métamorphose. Concept énergétique pour le quartier durable des Plaines-du-Loup.* Lausanne: Service du logement et des gérances, 2010, p.54

1.4.2. Lighting (lumière)

Light is considered as an important factor affecting human health through the nervous and hormonal system. Taken the fact that the average Swiss spends around 90% of the time in the interiors[11], the balance between natural and artificial lighting is of great significance. The natural lighting, with its luminosity around 10 to 1000 times greater than artificial one, should be particularly favored, allowing also to reduce the electricity consumption. Its good provision is an intrinsic feature of the buildings characterised by the relatively little depth of plan- that in turn is disadvantageous from the compactness of the form point of view. This can be overcome with deeper typologies which position the auxiliary spaces in the central part of the plan. To increase the profit from natural lighting, the bright finishings are advised in the exterior spaces. Their quasi-horizontal position reflects well the diffused skylight, which is particularly precious during the autumn and wintertime.

The counter-side of the sunlight provision is the risk of excessive heat gain that must be obligatory avoided. The subchapter 3.2.1 Heating and cooling discusses in detail the complex relation between the light and heat provision, as opposed to summertime overheat.

1.4.3. Air quality (qualité de l'air intérieur)

Inasmuch as the lighting conditions, the air quality of the interior remains a key issue for the human well-being. In the progressively more air-tight buildings the need for performant ventilation is gaining in importance. The technology of heat exchangers, which recovers the heat from the evacuated air, is included in almost all of the presented projects, and has virtually became a standard solution. It is however varying at the level of recuperation efficiency rate.

The ventilation strategy considerably influences the needs of heating, therefore in the most economic buildings (like house in Bennau) the measures are very strict: the windows cannot be opened but ajar. It allows only for rapid ventilation, in order not to cool the thermal mass. Possibly, the natural ventilation shall not be totally abandoned, for it does not require mechanical operation (e.g. lets cool the buildings during nighttime). Unlike the mechanical extraction, which is an energivorous process that might induce the electricity consumption reaching up to around $0.3 Wh/m^3$.

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[11] Office fédéral de la statistique, 1999

Lastly, the higher the degree of insulation and airtightness, the more adverse effects of thermal bridges and vapour-barrier ruptures appear. The flawless execution, as well as correct dimensioning of ventilating system is indispensable to avoid excessive humidity, condensation or fungus, all of which are detrimental to the human health.

1.4.4. Radiation (rayonnements)

Most importantly, this subchapter warns against the harmful effects of radon, which is the second cause of lung cancer (after the tobacco). All new investment localisation shall be verified with the radon-risk map in order to include preventive measures into design. Also the construction materials should be tested in this respect, as some of the granits, plasters as well as tiles glazings might induce extra radiation. This issue, however, has not been raised in any of the discussed projects.

1.4.5. Summer overheating protection (protéction solaire estivale)

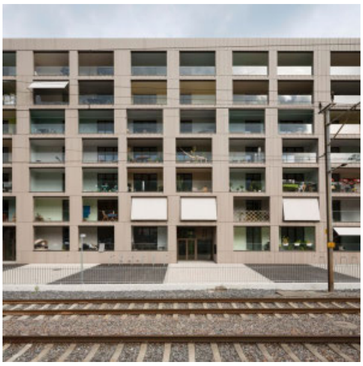
Apart from providing proper climate in summertime, the important goal of this recommendation is to avoid the mechanical cooling to maximum possible extent, preferably with the passive means. Certain rules of thumb are provided as a point of departure for the design, for instance avoiding glazing more than 50% of the facade surface (or ⅓ of the energy reference area[12]), The other passive means include the shading elements (as balconies, eaves, blinds etc.), nocturnal ventilation and the thermal mass. This particular recommendation shall not be considered separately from the energetical issues, as the sun is an important source of heat gains. It is discussed in greater detail in the subchapter 3.2.1 Heating and cooling.

1.4.6. Noise and vibrations (bruit, vibrations)

The theme of anti-noise and vibration protection rarely appears within the discussed pool of projects, as they basically comply with the norm SIA 181. In regard to exterior sources of noise, like the infrastructure, the extra measures were taken in Sihlbogen Areal which is located along the suburban railway line. The flats are facing the tracks indirectly thanks to the loggias with full

[12] According to the norm SIA 416/1:2007: the sum of all slabs (including the underground), which are within insulated envelope and whose exploitation necessitates heating or air-conditioning.

glass balustrade serving as the sound protection. Concerning the Eikenott, it is bordered by the A1 highway, which has been already equipped with the noise-barriers within this particular section. The housing is additionally screened from the road by green facades of the superelevated parking.



17. Sihlbogen

18. Eikenott

The other mean of noise protection is interrupting the visual link with the source of noise. It could unfortunately deteriorate the daily surveillance of e.g. the interior courtyards that are often the noise generators- which collides with the previously discussed criterion 1.4.1 Security.

2. Economy

The second major domain of development is the economy. Above all, this chapter emphasises the importance of holistic financial balance of buildings' life-cycle. A comprehensive anticipation of costs is advised in regard to consecutive phases of construction, exploitation and finally the renovation or demolition. Naturally, some of the intermediary cost are imprevisible, nevertheless there exist a variety of means to minimize the exploitation and renovation expenses. The domain of economy is split into three major parts:
-built fabric
-investment cost
-exploitation and maintenance cost
which will be reviewed following this order.

2.1. Built fabric (substance du bâtiment)

This recommendation is further divided and essentially advocates three points:
-the optimal usage of site
-building in a way that retains value over time (built fabric)
-inclination towards the current and future changes (flexibility)

2.1.1. Site (site)

The site recommendation mostly comprises the standard steps taken by virtually any investor: the exploitation of the existing conditions. The factors like: quality of view, the reputation or the proximity of public transports are usually valorized in the Swiss housing projects. Apart from that very standard approach, the consideration of noise/pollution emissions, urban planning and natural dangers is advised, even though those factors might not yet be evident at the stage of design. Also the dense forms of development are favored *a priori*, due to the dwindling resources of building land. Finally, the importance of proximities is particularly compelling, since they allow to reduce the commuting patterns, as stated in 1.3.1 Supplies proximity.

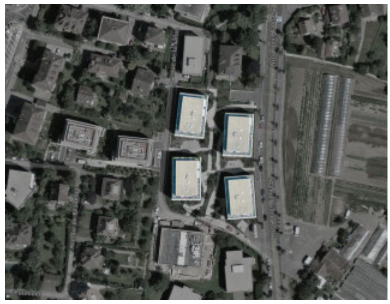
The sustainable approach towards site is illustrated by the Sihlbogen Areal, which proposes two rigid volumes within an idyllic location (bend of river Sihl and villa neighbourhood). The new development occupies a formerly industrial plot, imposing a considerable density. The brave typology is in a way the continuation of the city, also due to its excellent connection municipal transport system: the bus, night-bus and two SZU train stations within 200 metres.

19. Sihlbogen Areal, Zurich

20. Sihlbogen densities

The consideration of site efficient use are crucial point for the cantons of Vaud and Geneva, which are facing a rapid expansion at the moment. Apart from the dense new districts, even the singular realisations are maximizing the usage of the site- as in case of Victor Ruffy, which exploits the slope in optimal way, in harmony with the existing neighbourhood.

21. Victor Ruffy housing exterior spaces



22. Avenue V. Ruffy 57-63. Densities

The correct density is a crucial factor, especially after the revision of the Law on Spatial Planning[13], which highly restricts the release of new construction land.

2.1.2. Built fabric (substance construite)

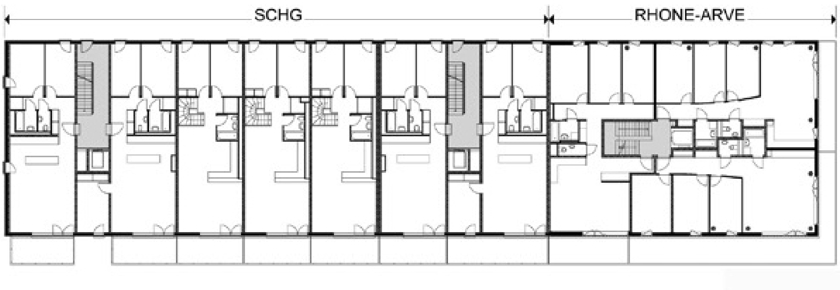
The following sub-item concerns building in a correct and up-to-date manner, in order to preserve building's value and assure its rentability throughout its exploitation period. It promotes the attitude contrary to short-time profit, which is not rentable in the long run; in other terms it can be expressed by *poor people cannot afford cheap things* concept. This very recommendation seems however to fall into scope of interest of any responsible investor and owner and thus does not introduce any unpreceded value in terms of sustainability.

2.1.3. Flexibility (structure du bâtiment, aménagements)

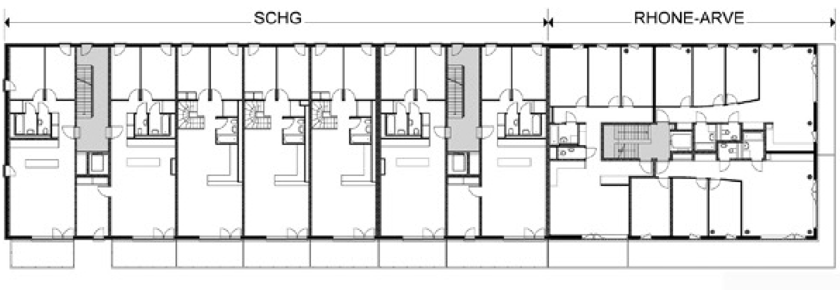
The the third point deals with the aptitude of the new building towards the current and future changes. Foreseeing the flexibility towards different patterns of occupation is an enormous asset from the sustainable point of view. On the one hand it is a considerable economy of grey energy once the building is transformed, and not demolished-reconstructed. On the other, the adaptability is a way to preserve its good market positioning and provide the long term rentability. An illustration of flexible and anticipative approach towards the planning can be observed at Hegianwandweg estate in Zurich. The load-bearing structure is formed by the concrete core and the perimeter posts. The light partition walls allowed for the majority of apartments to have

[13] Loi sur l'aménagement du Territoire révisée, 1.05.2014

unique layouts. The Victor Ruffy housing is based on the very same principle. The potential for change is present in the floorplans of Pommier B1 housing, which is composed of *maisonette* units. The ones which are adjacent to vertical communication shafts posses the second entrance in case of later rearrangement of the apartment.



23. Pommier B1, impair floors



24. Pommier B1, pair floors.

2.2. Investment costs (frais d'investissement)

Principally, this chapter discusses the influence of initial investment cost upon the later generated expenses (those latter will be specifically discussed in the chapter 2.3). Apart from the relation between one-time investment and exploitation period, the wide problematic of the external cost is also included in the last point of the chapter.

2.2.1. Life-cycle cost (coûts et cycle de vie)

The first point, life-cycle cost, suggests to approximate the ratio of already mentioned singular initial investment and later exploitation. Even though the building's life-cycle is not entirely known, relying on feedback from other projects is advised. Undoubtedly, the integration of sustainable solutions increases the initial cost, when compared to traditional construction techniques complying with current norm SIA 380/1. This might however become compensated by e.g. lower energy consumption, or in ultimate case, the free energy once the equipment has been amortised (positive energy house).

According to the interview with Daniel Lengacher, the author of Kloster Wesemlin housing, the initial overcost caused by sustainable approach pays off during the building exploitation. This is also confirmed by a conversation with atelier Lorenzo Giuliani and Christian Hönger concerning the Kappenbühl estate in Zürich[14] (though not energy-labeled). According to the feedback received from the houses compatible with German standard of *Passivhaus*, with an initial overcost is of 5%, there can be achieved a house that would annually consume 1.5l of mazout per square meter, instead of 6l. Summing up, the extra costs fit approximately within 10% of initial investment allowing for 20% savings on energy reduction[15]. Evidently, it is beneficial not only from the financial point of view, but also environmental one. It seems therefore that upgrade towards sustainability is not an enormous additional expense and allows for economic exploitation until the last stages of its life-cycle.

2.2.2. Founding (financement)

The subchapter "founding" is of purely economical character. It revolves around the traditional notion of the investment return, which in case of sustainable economy has a broader field of application. Ideally, the amortisation of the building should ultimately provide the means for its reconstruction or renovation. The increased amount of return can be compensated by the smaller running costs, building's longevity and flexibility.

In regard to sustainability and funding it is noteworthy that there exist two major model of financing on Swiss real estate market: the private investor and the cooperatives. The difference is that the cooperative is a particular type of investor who builds for himself- therefore is readier to accept bigger initial investment in return for lesser maintenance cost and durability. This kind of approach is clearly advantageous in terms of sustainable development and often results in favorable price-quality ratio. For instance, the rents in Hegianwandweg estate, despite its innovative technology, are equal with the cantonal average.[16]. Regarding the Kraftwerk 1, those values are even lower. Apart from the private initiative, there are institutions supporting the sustainable design. For instance, the application of the energy efficient wall

[14]Strumillo, Jan. *Economic Backbone of Swiss Sustainable Housing: Case Studies*. Zürich: ETH, 2008, p.90
[15] *Ibid.* p. 115
[16] *Ibid.* p. 66

panels in Pommier A and B2 was possible thanks to the Banque Alternative Suisse which supports the innovative projects; additionally, the subsidies from the Cantonal Energy Department were granted for that purpose.

2.2.3. External cost (coût externe)

The last point of the chapter is also the most visionary and future-oriented. It deals with the external cost, which can be summarized as a cost of pollution related to human activity. Up to now it is paid in whole part by the collectivity, in different forms: surcharge on energy bills, fuel excise taxation or CO_2 tax. According to SIA 112/1 recommendations, this financial compensation should be levied directly from the pollutant (i.e. industry or transport companies). One of the methods is proposed by the Swiss party Vert'libéraux that postulates replacing the VAT with the energy tax. It will be imposed on non-renewable fuels and is believed to accelerate the shift towards renewable energy. As long as the fossil fuels are not renounced, it might happen that those surcharges will be automatically reflected by the prices of products and services, thus finally paid by the collectivities.

Grasping of the external cost is therefore a hardly quantifiable task, since it is almost impossible to assign it particular entities. Even though its total elimination is impossible, all the measures aiming at:
-minimizing the usage of pollutants
-mitigating noise
-garbage management improvement
are worthwhile, as they are capable of at least minimizing it.

2.3. Exploitation and maintenance costs (frais d'exploitation et d'entretien)

Insofar as the previous paragraph stressed the importance of the initial investment, this one discusses the operating expenses. It is categorized into two domains: the exploitation cost and, separately, the renovation.

2.3.1. Exploitation and maintenance (exploitation et entretien)

The maintenance and exploitation constitutes the biggest part of the building's lifecycle budget. Principally, the aim of sustainable economy is to minimise any cost without however compromising on the quality. From the material and architecture point of view it essentially feeds through into lowering energy bills and easy to upkeep materials. As the transport costs has nowadays become negligible it appears that many of the oversea finishing materials (e.g. exotic wood and stone) might fully compete with local products in respect to their price and durability. It is however possible that the imported products are of higher embodied energy content, which should be taken into consideration by the architect. This aspect is further addressed in the chapter 3.1.2 Environmental impacts.

2.3.2. Renovation (rénovation)

The potential for renovation should be anticipated from the very beginning phase of the project, in order to prevent the subsequent cost from becoming greater than that of the new construction. With a certain dose of anticipation the expenses might be considerably minimized, contributing therefore to buildings longevity and good position on the market. The illustration of such approach is using the easily replaceable and accessible components, and secondly, relying on materials synergy.

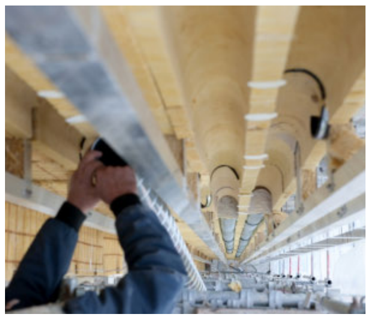
The idea of materials synergy can be explained on the example of the typical floor composition[17]. Instead of designing the following layers:
finishing - screed - PE sheeting - insulation - slab
one might consider simplified composition where the screed is at the same time the finishing (for instance terrazzo). This solution is particularly advantageous for its economy, but also from the perspective of the renovation. The life expectancy of the insulation is the shortest, so in order to replace it, one needs to destroy the upper layers which are not yet obsolete. In case of the aforementioned simplified floor, there is one layer less that will be prematurely discarded.

The other approach toward the renovation is the choice of the life-cycle strategy: long or short. There is a choice between durable composition that will be entirely changed after a long period of time, or easily changeable floor for rapid and little interventions- assuming occasional thrashing of the material that is still new.

[17] Hegger, Manfred. *Energy Manual: Sustainable Architecture*. Basel: Birkhäuser, 2008, p.33

Overall, the idea of renovation is priceless, mainly for saving the embodied-energy of the already existing structure. The evaluation of its economic sense is facilitated by the software (e.g. EPIQR) that approximates the potential costs with 10-20% precision. This field is currently a particularly promising branch of occupation for the architects, since ¾ of european real estate resources are considered as obsolete[18]. The situation is progressively more pressing, due to the norms getting ever stricter as well as growing prices of land and energy. As shows the case of the Gilamont towers in Vevey, it is feasible to upgrade the old structures to Minergie standard, that is already ahead of the applicable norm SIA 380/1. The two buildings have been insulated from exterior with glass-wool, as well as equipped with heat-recovery ventilation. The ducts are routed in the layer of insulation, which is a custom solution. The consumption of mazout has dropped by factor of 4 down to 60 000l per year. Due to the project localisation at the gate to Vevey, the two blocks were additionally painted with artwork commemorating Charlie Chaplin. More than a simple renovation, it is a manifestation of engagement to ameliorate the environment (also in the social sense). This might justify the considerable cost of the project amounting to 20 mln of Swiss francs.[19]

25. Gilamont towers, Vevey



26. Custom cut glass-wool sheets

[18]Hegger, Manfred. *Energy Manual: Sustainable Architecture*. Basel: Birkhäuser, 2008, p.39
[19] www.isover.ch

3. Environment

The last group of indicators focuses mostly on the technological and measurable solutions. It is treating broad issues of: materials, energy, infrastructure, landscape and therefore constitutes the main part of this work. The domains' chapters strongly interfere, leading to conjoint solutions which are presented with help of extended case studies. They are chosen to reveal the multi-dimensional nature of the energy-related questions. This part is intended to raise awareness of the means to be applied in further diploma project.

3.1. Construction materials (matériaux de construction)

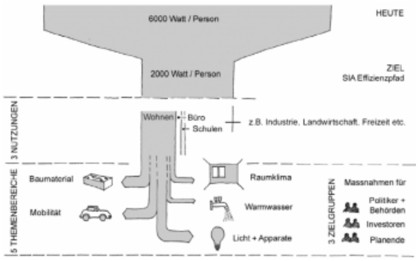
In the common understanding of energy efficiency issues, it is the exploitation energy that appears in the first place, as it is perceptible by e.g. interior temperature or lighting. It appears however, that the amount of energy required to treat the materials during their whole life-cycle is not at all negligible and should be also taken into consideration.

3.1.1. Raw materials (disponibilité de matières premières)

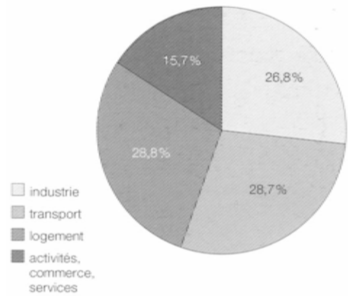
The subchapter strongly emphasises the need of rational management of the construction materials. Its clear manifestation is the privilege and priority granted to raw, and recycled-raw materials; both of which are considered as easily available, thus engaging relatively little energy to deliver. Concerning Switzerland, these are for example: the local wood, the gravel and clay. On the other hand it is advisable to economise scarce secondary ressources (like copper or exotic wood), whose rate of renewal is slow, processing and transport costs are significant.

3.1.2. Environmental impacts (impacts environnementaux)

The care for the environmental impact is due to the heavy presence of construction-related industry in balances of the greenhouse gases emissions as well as energy and resources consumption. The total of the work invested into delivering a construction element on site is equivalent to its embodied energy, which according to sustainable development ideas, should be minimized.



27. distribution of 2000W



28. energy consumption (Germany, 2005)

According to the scheme presented above which can be considered representative for the western Europe, the construction and transport are leading consumers of energy. Globally, approximately 40% of greenhouse gases are released by construction sector. It consumes around 50% of extracted resources. On european scale, about 60% of waste originates from building sector. Moreover, the exploitation of the building has 40% share in total energy balance[20].

Looking through the optics of 2000W Society, which assigns a fixed quota of power to each branch of human activity, it appears that the aforementioned industrial consumptions are largely included into the Housing branch. The somewhat elusive link between embodied energy of the materials and later exploitation of the building is illustrated by the following example. In case of the Passivhaus standard-compatible building, it appears that its embodied energy is of 500-1500kWh/m^2. The heating need could be as little as 10kWh/m^2 <u>annually</u>. It would therefore take 50-150 years of heating to touch the amount of energy stored in the construction, which shows the importance of the dimension of the embodied energy[21].

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[20] Hegger, Manfred. *Energy Manual: Sustainable Architecture*. Basel: Birkhäuser, 2008, p. 26

[21] *Projet Métamorphose. Concept énergétique pour le quartier durable des Plaines-du-Loup.* Lausanne: Service du logement et des gérances, 2010, p.28

In respect to the materials, it is largely under influence and responsibility of the architect to provide the construction complying with the set limits. To minimize the embodied energy, there are two fundamental measures:

- choice of materials
- compactness of built form

The embodied energy balance of the materials is affected not only by those load-bearing ones (which appear the most voluminous), but also also the insulation and finishings, that are highly processed compounds. The calculations must rely on the estimations, since it is impossible to define the exact amount of energy used in the process; nor to set the limits of the analysis. For instance, the energy used by workers to commute to the factory- which is by no means negligible in case of suburban production centers relying almost exclusively on car transport- is highly approximative.

To illustrate better the problematics of embodied energy, the case of concrete will be presented. First and foremost, the concrete basic ingredients (gravel and sand) are easily available natural materials that do not require processing except for the transport. It is the production of the binder (cement) that needs over 1000°C heat to decarbonize the lime, which is additionally releasing the carbon dioxide. While setting, the concrete ties the water, which is an irreversible process. Finally, the problem of recycling arises, which requires more energy, than for instance wood, that might be simply burnt. The major concrete companies like Holcim have taken measures to render the concrete more sustainable, which is inevitable due to its ubiquity and wide range of applications. The cement is becoming partly substituted with fly ashes; the factory ovens are fired with garbage (that can be considered a renewable resource), thus allowing to reduce fossil fuels share. The Portland cement might be replaced with the blast furnace cement, containing 50% less embodied energy[22]. Additionally, the part of the gravel might be replaced with the crushed concrete, which only slightly weakens the properties of the final product, but increases the recycling rate. Moreover, the rainwater quality is sufficient for the preparation of the mix and rinsing, thus it does not overload the treatment plants. The question of proximities is also crucial, which favors the countries like Belgium or Switzerland as the medium distance to the factories is relatively little. Finally, the concrete is a long-lived material which allows to amortise its embodied energy over a long period of time. At present, the its sustainable aspect is a topic of continuous research and the concept "green-concrete" widely spreads among the producers, resulting in 30-40% reduction of embodied energy.

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[22] A. De Herde, *Le béton et la construction durable*, Bruxelles: FEBELCEM, 2010, p.11

Apart from load bearing materials, the insulation requires equally careful choice. The popular materials like EPS, rock and glass wool are of high embodied energy content (per unit of volume), despite the significant economies achieved during the later exploitation period. There are however strategies allowing for sustainable insulation of low U-value and low embodied energy- however at the expense of the wall width. In case of Cressy apartment house the insulation consists of two layers: 35 cm of the cellulose (low embodied energy) and 5 cm of rockwool. Since it is a wooden structure, the posts are integrated into insulation layer and do not expand any more the wall dimension, which would be economically disadvantageous. The determination of the materials composition is thus a multi-criterion choice, crucial for the building's balance of energy, which depends to large extent on the local conditions.

Secondly, it is the factor of form that counts: the compact structures are privileged, as they provide more usable space per square meter of the envelope, thus require relatively less construction materials.

To conclude, despite the ubiquity of the concrete, a trend of wooden housing is emerging. Almost half of the projects presented in the pool exploit wood in their load-bearing structure, thus significantly lowering the embodied energy. These are: Hegianwandweg, Victor Ruffy, Cressy, Kloster Wesemlin, which contain however the concrete core. The spectacular example of exclusive use of wood and compatibility with anti-fire policy is the Casa Montarina in Lugano, whose only concrete part are the foundations.

29. Casa Montarina

30. Casa Montarina wall prefabricates

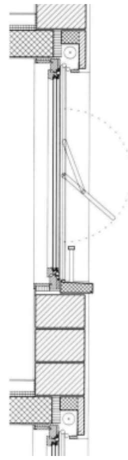
3.1.3. Pollutants (polluants)

The subchapter pollutants postulates the reduced usage of the potentially harmful materials, which are classified in six groups (paints, sealing, composite wood panels, glues, synthetic materials and glues). Obviously, it is impossible to exclude these, but the rational management is advised. This recommendation is valuable in regard to their relatively high content of embodied energy. The house in Dübendorf is a showcase of pollutant-free architecture, for which has been labeled Minergie-P-Eco certificate.


31, 32. House in Dübbendorf. Larch cladding, recycled concrete, wooden window frames

3.1.4. Deconstruction (déconstruction)

Deconstruction chapter encourages the application of easily recyclable and separable materials and compounds. In this regard the composites and glued connections present difficulties in terms of their replacement or discarding. In scale of the whole building, the simple wall composition facilitate the sustainable deconstruction. The monolayer walls are not excellent considering the 2000W Society requirements, however they comply with current SIA 380 standards. For example, the Hagenbuchrain estate is erected from hollow brick without exterior insulation; its usage is only limited to prevent the loggia-issued thermal bridge, as well as acoustic-layer of the slabs. The building is not energy labelled, although its need for heating is approximately 80% smaller compared to SIA 380/1 values.

33, 34. Hagenbuchrain estate, uninsulated exterior wall detail.

3.2. <u>Exploitation energy (énergie d'exploitation)</u>

It is the core chapter of the work, which is also crucial to meet the criteria of 2000W Society. The exploitation energy includes: heating, cooling, hot water preparation and electricity. In modern housing those systems are often interdependent and individually dimensioned- therefore uneasy to analyze separately.

3.2.1. Heating and cooling (besoin de chaleur ou de froid)

The clear aim is to minimise the amount of energy needed to maintain the proper interior climate. The main steps are:
-proper insulation and protection (e.g. from wind and sun)
-valorizing the renewable energies
-compact form
-thermal mass and temperature zoning.

Finally, apart from the building technology, the awareness of the occupants and their habits appears an equally important factor to consider.

Firstly, the continuous insulation might be considered as a new paradigm of current epoch[23]. Gradually it will require rigorous of application comparable with buildings structure, whose continuity allows to conduct the flux of forces.

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[23] Voellinger, Thierry. *Le Mur À Haute Performance Thermique: Évolution Et Perspectives De La Façade Porteuse En Béton Préfabriqué À Genève Dès 1973*. Lausanne: EPFL, 2012. p.75

Similarly, the insulation should avoid any ruptures and thermal bridges. Their loss transmission increases proportionally to the degree of buildings tightness and insulation capacity. It therefore causes problems from the architectural point of view, since often disguises the true structure and must be protected itself with yet another, decorative material (which, incidentally can be considered as a hallmark of modern architecture). The other architectural consequence is the problem of balconies and other thermally broken connections, that would also account as thermal bridges. Different strategies are currently being tested, which is manifested by the unpreceded variety of facades solutions in contemporary architecture. The ultimate achievement is the transparent insulation, based on phase-changing materials. Such wall is not anymore considered as of static U-value, but a dynamic one. It allows to profit from low incidence angle of winter sun, while reflecting the acute summer rays. The example of such technology is found at Pommier A and B2. It is assembled from the panels Lucido, which are of extremely small width (26 cm) as for Minergie-P-Eco compatible building. To compare, the Cressy house bears the same certificate, which is however achieved with the traditionally composed 40 cm thick wall. Economy-wise, it is a clear gain of usable floor surface.

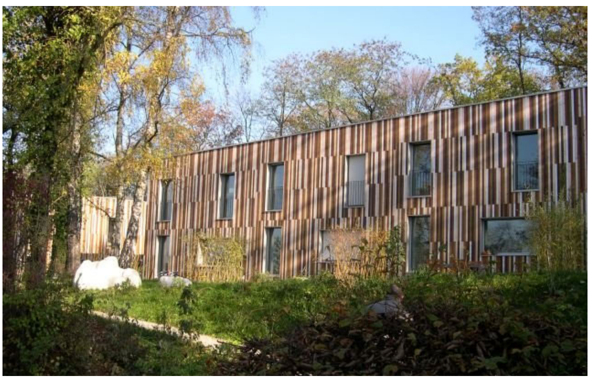
35.Lucido panel composition

36. Pommier A facade.

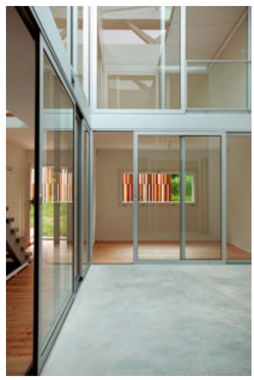
Thus it appears that the most direct way of obtaining heat is the solar energy, also through the windows. This however should be conceived carefully to avoid the excessive radiation and hence overheating. At the same time, the protection can serve further as a mean to eliminate the need of air-conditioning. Since it is impossible to analyse those issues separately, the two short case studies are proposed:

Am Rebgässli

The house profits from solar gains thanks to the vacuum-tube collectors installed on the roof and the glazed, covered interior patios- which constitute the buffer zone, which is slightly superelevated above the roof (gathers the hottest air). Exterior facade windows are not considered as the collectors of radiation, and their size is minimized to reduce the heat losses. The problem of insufficient lighting of 16 m deep units is solved by the inner patios, that prove efficient in the 2 storeys house. The passive gain system is backed-up with gas-furnace. The patio skylights are human-operated and are also capable of reducing the need for cooling in the summer time. The effect of solar-chimney across the two-storey high houses is powerful enough to suck the chilled air from the basement. The need of cooling/heating is further reduced thanks to buried pipes, which temper the air temperature by 3°C according to the season.



37. Am Rebgässli row-house typology



38. Inner courtyards.

Considering that patios are glazed against the close airport noises, and apartments ventilation is equipped with heat recuperation, the project is a perfect display of well integrated technological solutions- and is labeled Minergie-P certificate.

Kraftwerk B Bennau

The house is equipped with solar panels on the pitched roof and facade, however only those latter are used for heating. The full height triple-glazed windows are also treated as collectors, being equipped with external shutters to avoid overheating. Additionally, the building’s core and floors are concrete and serve as thermal mass. The ventilation strategy also contributes to limit the heat loss: the intake is laid underground and the outlet is equipped with heat exchanger. Moreover, the windows can be only opened ajar for rapid air renewal. Together with generous cellulose insulation (walls and roof: 36-44cm), the final heating need is reduced to only 13.8kWh/m^2×year (compared to 15kWh/m^2×year of German Passivhaus standard).

39. Kraftwerk B, south-western facade

40. Adobe render finishing of massive walls

Finally, the house is a complex and holistic system which takes into account preparation of hot water, as well as electricity and heat that is fed to the municipal grid. Since it also exploits heat pumps and water storage tank, the example of Kraftwerk B will be further referred to in the end to fully illustrate the interdependence of the subchapters and their related systems.

<u>Solar gains and protection</u>

The buffer zone, as in case of Am Rebgässli, can take other forms than that of patio: it can be a double facade (which is more often applied to office buildings) and winter-garden. The latter solution is employed in two projects: the Fehlmann site in Winterthur and Vallée de Jeunesse housing in Lausanne. It is called a four season room, that is in fact an insulated loggia. This solution is one of the answers towards the problem of balconies' thermal bridge- which in both cases is non-existent, thanks to peripheral insulation. It is an important input for the later diploma project, which due to construction mode in prefabricated concrete will call either for a stack of prefabricated loggias, or the presented wintergarden room.

41. Vallée de Jeunesse 4-season room

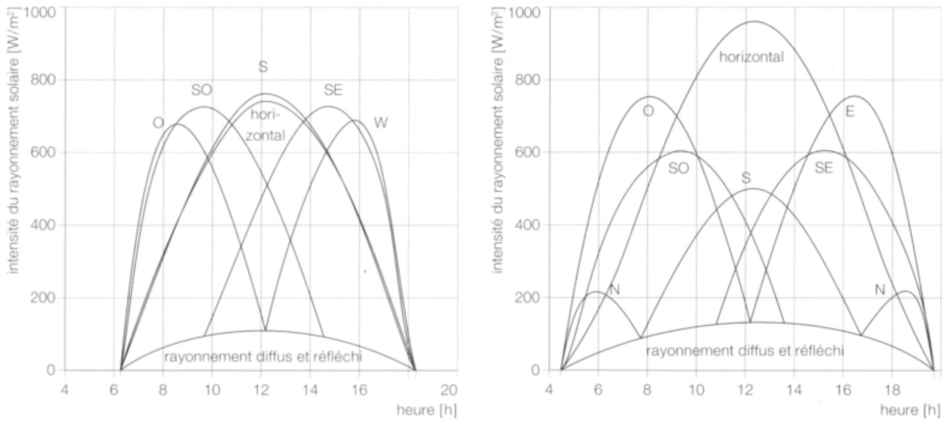
42. Fehlmann site

Concerning the orientation of the windows, in Swiss conditions, it is the southern one that is considered the main collector, all year long. At the same time it should be well protected against the overheat. This protection should also apply towards the eastern and western openings, as during the summer solstice they transmit even more radiation than the southern window, due to the angle and time of exposition. The north window, in an overall balance is considered a source of heat loss, not the gain- therefore its size should be minimum. The exact size and position is determined by the calculations- so will happen during the phase of project. The sun-depending window design is well observed in Cressy house.

43. Cressy northern facade

44. Cressy, southern facade.

According to the schemes, the overheat may also come from the roof (the *horizontal*-marked curve in the center of the scheme), as well as internal charges, which are however more significant in case of the office buildings.



45. Solar radiation intensity (Stuttgart, equinox and 22nd June)

The shading protections can be chosen from wide variety of louvers, shutters and blinds. The external ones are generally more efficient due to direct reflection of radiation, but are exposed to bad weather, notably the winds. On the other hand the internal blinds are fixed in a glazing module and therefore hardly replaceable in case of defect; they also prove less efficient, as part of radiation is reflected back, heating the blinds and the window. Finally, the least efficient system is the interior set of blinds. Apart from the adjustable mechanisms (manually or electronically), a simple and almost ancient solution of balcony, window eave (or an overhang) still proves very competitive- as seen in Cressy southern facade.
Optimally, the protection should not totally obscure the interiors. The windows should be also configured in terms of required interiors' lighting, which generally favors maximal height of the lintel (allowing deep penetration by light). On the other hand, the floor-to-lintel high glazed surfaces might provoke draughts due to the temperature gradient on their inner surface. Lastly, apart from technical considerations, importantly the essential role of framing the views should not be abandoned. Taken the numerous factors required to determine the windows, it is impossible to provide a universal written description; it is therefore a major theme to address in the diploma project.

<u>The compact form</u>

The third element allowing to limit the heating and cooling need is the compactness of the form, expressed by the ratio of the thermal envelope surface to energy reference area. If kept low, the surface transmitting the heat (in both directions, depending on the season) is minimal and keeps interior climate stable. The form factor is particularly decisive in case of old buildings, as they are usually poorly insulated, unlike the new structures- where it is affecting less the demand for heating/cooling balance[24]. Nevertheless even in new constructions, the compactness allows for other economies: notably of material and thus, the embodied energy as mentioned before (subchapter 3.1.2 Environmental impacts).

Temperature zoning and thermal mass

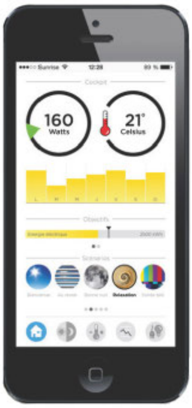
The buffer rooms and functional zoning may also contribute to the modest energy consumption. The most temperature sensible-rooms should be placed as close as possible to the core of the building, whereas the communications or storage spaces might serve as temperature transition zones placed close to exterior shell.

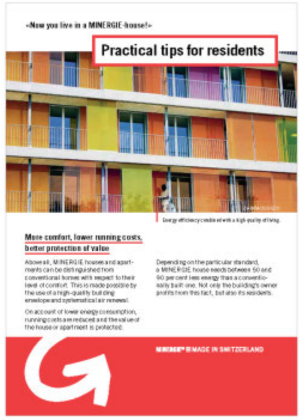
Lastly, the thermal mass is indispensable to provide a stable interior climate. It helps to equalize the daily solar rhythm of temperature. In case of wooden structures it is indispensable to prevent the “shack climate” having no thermal inertia, hence cooling and overheating rapidly. The finishing of the massive elements is crucial from the esthetic and energetic point of view- which might collide. So that the mass is efficient, its finishing must be specific: either none (e.g. bear concrete wall), or with specific kind of render, as i.e. adobe-based- which obviously might not always be considered visually sustainable.

User habits

There exist means to raise awareness of the occupants in terms of energy consumption, as the real economy comes not only from the technical equipment, but also from the human habits. It is also reflected by the Minergie brand publications, which apart from the designers, also address the advice to the inhabitants. For instance, at Eikenott district, the households are equipped with tablets displaying in visually attractive manner the amount of used kilowatts- which is however only informative.

[24] *Projet Métamorphose. Concept énergétique pour le quartier durable des Plaines-du-Loup.* Lausanne: Service du logement et des gérances, 2010, p. 90.





46. E-smart energy management

47. Minergie for residents

The Eichgut housing possesses a more strict system: the decentralized ventilation with recuperation and individual apartment billing. It turned out that this initially more expensive solution brought the stable reduction by 30% of the heating needs, due to more rational and controlled ventilating and heating by tenants.

3.2.2. Hot water heating (besoins d'énergie pour la production d'eau chaude)

Within the well-insulated buildings the amount of energy needed for hot water heating is comparable with the general heating. Except for the cases when hot water is provided from the municipal network, the presented projects exploit the solar heat and reservoir storage in different configurations. The specialized companies, as Jenni AG offer the holistic strategies related to the hot-water production and storage- and often link it with other fields, like those of ventilation and heating. The air-water and waste water-water exchangers are present respectively in Eichgut and Bennau housing in order to restore every little portion of energy. This is a hallmark of the sustainable approach, where otherwise residual heat is exploited to increase the efficiency.
In this subchapter, the economy of consumption is also the principal measure. It is often realised with the economic taps and mixers (for instance using the pressure reduction fixture, as in case of house in Bennau). Secondly, grouping the sanitary blocks across the building results in shorter pipelines and thus fewer losses. Finally, the individual billing is the ultimate measure as it is motivating from the financial point of view; e.g. the Victor Ruffy houses are operating according to this strategy.

In order to better illustrate the interdependence of the two preceding subchapters (“cooling and heating” and “hot water heating”), the full energy scheme of house in Bennau is described below:

Technical schematic of energy provision
Section with energy and ventilation concept, scale 1:250

1 Photovoltaic array
2 Sun position in summer
3 Sun position in winter
4 Waste air
5 Supply air
6 Wood-burning stoves
7 Underfloor heating
8 Radiator
9 Solar thermal system
10 Heat recovery
11 Ventilation system
12 Buffer storage tank
13 Seasonal storage tank
14 Hot water storage tank
15 Earth tube heat exchanger
16 Fresh air
17 Exhaust air
18 Heat transfer to neighbouring building

48. House in Bennau, energy supply scheme

The facade solar collectors satisfy 60% of annual demand for heating and hot water (including 100% during the summer months). The individual wood stoves power the bathroom radiators as well as basement storage tank of 6000l. The second one (insulated and seasonal) of 24000l volume provides the hot water and floor heating in case that individual tank output is not sufficient. The waste-air heat is first exchanged with the fresh air and secondly, fed into the large tank, by means of the heat pump. Whenever the fresh air needs further conditioning, it is heated with the coil (fed by floor-heating return flow). The fresh water is preheated in the same way. Finally, the cooled flow ends up in small tank, which increases the rate of heat absorption of the solar collectors. During the summer months (June-September), the house is able to additionally provide hot water for the 15-flats neighbouring building. The house is also autonomous in terms of electricity. The annual solar yield from the pitched roof panels is greater than demand; the surplus is transferred to public grid.

According to theoretical calculations, the house is categorized as zero-energy building. Its functioning scheme should be however discussed in terms of non-standard conditions, which has been the case during the relatively harsh winter of 2010. At that time, the interior temperature of 20°C has been assumed; which effectively has become 22°C. Moreover, the shutters originally intended for solar protection, were lowered during the winter time (glare and privacy), thus diminishing the solar gains. Due to the particularly low seasonal temperatures, an increased heat demand has been observed (by about 10%). In the looped system of instruments, it turned out that air-water heat pump is crucial for hot-water (also floor-heating) provision on the overcast days. The wood burning stoves serving as a back-up are manually operated and thus not always correctly exploited. The air heat exchanger, which is buried underground is little efficient on the days below -5°C. It can hardly condition the air above the level of frost, for which was intended. The additional heat comes from reverse flow exchanger and heating coil- both dependent on waste air and floor-heating water. The heat pump (air-water) set on 100% load, would only increase the losses through ventilation; moreover cooling the utility room and the ducts.

It seems that the looped system may not propel itself without the emergency external source of energy independent from the weather conditions- in this case- the stove. The house, after all, has astonishingly proved to be positive-energy, thanks to the electricity surplus that has outweighed the heating shortcomings. Overall, the planning took 4 years, which made the Grab Architekten (responsible office) specialize in the field of energy efficiency. Thanks to the pioneer conception it bears Minergie-P-Eco label, as well as has been awarded Norman Foster Solar Award, as well as Swiss Solar Award (2009).

3.2.3. Electricity (electricité)

Also in case of electricity, the promotion of rational management habits is indispensable. The monitoring systems apply here as well, however the experience from the house in Bennau provides a surprising feedback. The system of bonus-malus allows to track individual consumption, which alters the rent. Only the most environmentally-concerned tenants modified their habits; it turned out that quotas of order between 70-150€ were not motivating enough for the rest of inhabitants.

The other axe of potential economy is the use of efficient appliances, i.e. those of A++ class. The change comes almost naturally, as this kind of equipment is most often replaced. In the most advanced cases, the dishwashers and washing machines are supplied directly with pre-heated, not the freshwater, to minimise the share of electricity.

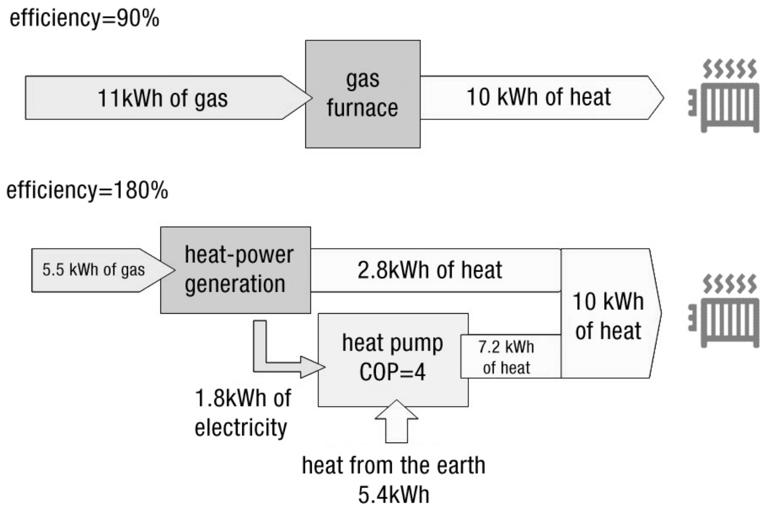
In terms of lighting (responsible for large part of domestic consumption), the direct current obtained from photo-voltaic panels could partly relieve the peaks, when coupled with LED fixtures. This concept however is still not mature enough for the implementation. Nevertheless, the conversion into alternating current brings good results. In case of relatively small houses, as Cressy containing 13 appartments, the internal needs might be almost entirely satisfied by 150 m^2 roof panels.

The onsite production is a last resort when further economies are not possible. According to 2000W Society criteria, as long as energy is renewable and produced on site it can be deducted from the balance. It spurs the rapid development of the photovoltaics technology, which already offer a wide variety of solutions: 0-90° angle range, as well as multiple colors, which allow for fully esthetic integration. The fluctuations of production are often equalized by connection with public network which handles the surpluses and shortages.

3.2.4. Operating energy coverage (couverture des besoins en energie d'exploitation)

This subchapter terminates the "Exploitation energy" chapter in a general manner, recommending the maximum share of renewable energy. It partly overlaps with previously discussed aspects, but also proposes supplementary points that were not treated before, most notably the usage of heat pumps and biomass-issued heat. Possibly, the garbage incineration could have been added into this point, as it is also considered a renewable source of energy.

In regard to the heat pumps, it is noteworthy that Switzerland is one of the leading countries using this technology. The most spectacular return rates (exceeding 100%) might be achieved under strict technological measures, when heat pumps are coupled with combined heat and power generation. This solution, although relies partly on a non-renewable resource (natural gas), could be implemented in the district of Plaines-du-Loup, that is deemed compatible with 2000W Society strategy.



49. Maximisation of the return rate

The use of heat pumps is particularly beneficial, since they reclaim the Earth heat with relatively little input of energy. Apart from heat-power generation, those pumps might be ran with solar-issued electricity. Using this combination together with garbage incineration and sun-powered mechanical ventilation (that consumes itself considerable amounts of energy), made the Eulachhof housing energy-autonomous.

50. Eulachhof (Swiss Solar Award 2007)

51. The southern facade

The onsite energy production- regardless of its form- has an advantage of minimum losses in transport, due to local distribution. Oppositely, it is subject to higher fluctuations of demand generated by relatively small community. Therefore the systems of heat stockage (e.g. tanks or car batteries) are indispensable. So is the connection to the public grid which, as already mentioned, serves an emergency backup, allowing for both: coverage of the temporary shortages, and on the contrary, feeding back the surpluses.

Therefore the energy balance is considered on annual scale, even in case of zero-energy development, as Eulachhof.

The garbage incineration could possibly complete the list of sources that have not been mentioned yet. The thermal power stations fired with litter are already operating (e.g. Tridel SA in Lausanne) and may be connected to the future districts compatible with 2000W concept. It is important to notice that the emission of greenhouse gases is unavoidable in either case: stockage or burning the garbage. However, the “thermal valorisation” does not only provide the heat, but also allows to reduce the area of landfills. It can be further argued that waste has indeed considerably lesser calorific value than fossil fuels. It is true, but one of the goals of sustainable approach is to limit the degree of the dependency on low-renewal rate ressources. Finally, the garbage incineration might partly provide the industrial heat (e.g. cement factories), whose high temperatures guarantee their total incineration (in terms of calorific value and basic chemical composition of the residues).

3.3. Landscape (sol, paysage)

In the biological sense, preserving the virgin surface of the earth is considered crucial for the stability of natural environment. Naturally, the built development poses threat towards this issue, unless it respects fundamental points concerning the biodiversity preservation, water-table level etc. The guidelines for rational land management are presented below.

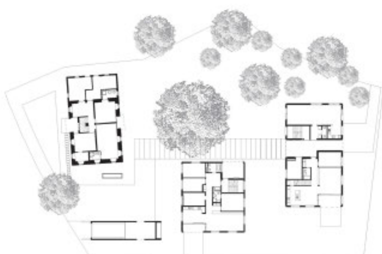
3.3.1. Land demand (superficie des terrains)

This chapter raises awareness of the disappearing construction lands (competing with infrastructure and agriculture). Thus efficient management of the grounds is advised, favoring the high densities. It requires reconsidering the traditional typologies: the single family-house might evolve into *habitat groupé,* preserving most of the advantages of an individual villa- while imposing high density. Regarding the collective housing, the problem is complex, since the Swiss would often couple it with secondary, private residence, which does not appease the rate of land consumption.[25] As well as the architects, this issue concerns the urbanists, as it falls into scope of territory management.

[25] Girard, Philippe, *On en parle*, broadcasted: 9.12.214, RTS La 1ère

3.3.2. Exterior spaces (espaces exterieures)

In principle, any building activity is considered as aggressive towards natural environment, therefore an extreme precaution towards saving the fauna and flora is postulated. Concerning the biodiversity in urban conditions, there are rare interventions aiming further than green roofs and gardens, which has almost become a standard. These, however, are often reduced to their filtering and retention function, whereas they could have served as a terrace accessible for the inhabitants, recompensating the intensive use of the plot on the ground floor level. At the moment, these are treated as tertiary spaces without a specific public function. Instead, the measures are taken to render maximum of the ground floor surface as bioactive. It can be observed in Pommier A and B2, whose superelevated parking slab is a common garden surface, continuing into promenade. Apart from vegetation, it offers the ponds which milden the microclimate, as well as attract the animals. The concrete pavements neutralize the naturally acid rain waters, thanks to the content of magnesia and lime. The particularly subtle approach is observed in case of Kloster Wesemlin, where the position of ancient trees and their rootballs affected the volumetry of the project.The non-hardened surfaces keep the water table at natural level. This in return brings better chilling potential during hot days, thanks to facilitated evaporation.



52.Kloster Wesemlin

53.Sonnex

The abovementioned examples are of punctual scale. Due to scarce natural resources, Switzerland does not have to recultivate e.g. vast post-mining areas, as happens in neighbouring Germany recreating the entire landscapes. Instead, it is the post-industrial sites that draw attention, not only because of the environmental purposes, but also economical ones. Apart from Plaines-du-Loup, the other ecodistrict developed by the city of Lausanne is found at Malley, former industrial land.

54. IBA Emscher Park (D)

55. Malley, the future ecodistrict.

3.4. Infrastructure (infrastructure)

This chapter concludes the Recommendations evoking three points that has already been partly touched. Those are: mobility, garbage management and the water issues.

3.4.1. Mobility (mobilité)

The goal of the "mobility" point is to induce the shift from private to public transport. In this regard, the site location and availability of public transports in vicinity is of crucial importance. Apart from the light mobility (discussed in chapter 1.3.2 Light mobility), the car issue should draw special attention. The cars are particularly energivorous for the following reasons:
-the efficiency of fossil-fueled, combustion engine is of around 25-30%
-the average occupation rate is of about 25-30%.
-unfavourable ratio between own weight and passengers
-the related infrastructure's content of grey energy

The means to limit its usage are numerous, and do not necessarily need to be as strict, as in case of Hunziker Areal in Zurich, that is conceived as car-free settlement. The car-sharing platforms, either private (often funded by inhabitants) or the commercial ones like "Mobility", are gaining popularity for the financial economy they offer, while preserving a large degree of independence inherent to the car.

It is particularly noteworthy that electric car-charging station is one of the common methods of electricity surplus storage. The Eikenott district is equipped with such charging station- as well as Mobility and Velopass/PubliBike borne. Moreover, it has own dedicated bus stop and the railway station is reachable within 15 minutes walk. To encourage the inhabitants, the parking is intentionally distanced from the houses, and serves as sound protection from the nearby motorway. The cooperative Equilibre inhabiting the house in Cressy, has also renounced the usage of private cars, in favour of own sharing platform. Its 13 appartments require only 3-4 parking lots; thus underground parking construction could have been avoided, meaning significant economies in terms of grey energy.

3.4.2. Garbage (déchets d'exploitation)

One of the keys to sustainable development is the closed-loop economy, which manifests itself in planned waste management. Ideally, the garbage deposit should be minimized (in favour of recycling), for its land-consumption, green-house gas emissions and eventually soil pollution. In order to maintain the high rate of recycling is important to maximally facilitate the sorting of the garbage. It can be encouraged by proper placement of the bins on the frequented paths. The technology of underground storage eliminates the odors as well ass liberates the surface. The sorting and composting of the waste facilitates the further recycling and prolongs the life-cycle of the products.

3.4.3. Water (eau)

Even though Switzerland possesses considerable resources of water, the rational management principles should apply as well, as long as the water is chemically purified. The treatment plants require considerable areas of land (around 0.5-2m^2 per person)- but they could handle larger population provided it takes measures of economy. In general, the fresh water usage might be reduced by economic taps, no-mix or dry toilets, leak control and revalorisation of the rainwaters. The water treatment plants, apart from their basic function, might also contribute to the heat and electricity production. The sewage sludge and methane, which are the final residues, might be burnt as happens in the Gland's municipal plant. The building is energetically independent and has received "La Médaille d'Eau" that is a federal award.

Nevertheless, the closed-cycle is again an ideal and the house in Cressy is the pioneer case of residential building in Switzerland, that does not reject the waste waters to sewage system. The brown water from the dry toilettes is composted, whereas the grey water is treated on site, thanks to the reeds planted in sand, serving as a natural filter. Later, it is fed into the local pond, together with the rainwaters. The average water consumption per member of the cooperative reaches 60 litres annually, compared to the national average of 160 litres[26].

[26] http://www.cooperative-equilibre.ch/projets/cressy/

Summary

In order to summarize main interactions across the domains of: society, economy and environment, a concise balance is provided. It is the basic foundation for the project, as it allows to judge the future decisions from the multiple points of view. The detailed one comes in next chapter with the analysis of site-related requirements. As the recommendations come from different fields, their conflicts and synergies are inevitable. They are listed below in order of relevance to later project.

Solutions in competition:

- The windows and skylights considered as the heat collectors should be at the same time well-protected from causing the overheat. The protection mode usually marks significantly its presence on the facade and thus should be considered from the beginning in order not to compromise the design. The size and position of the windows, apart from architectural intention, should be verified with the calculation-determined configuration.
- The liberty of material choice must be confronted with embodied energy limits that poses strict constraints; the obligatory elements such as the reinforced concrete anti-seismic wall might significantly affect the balance. There are however measures to reduce the content of embodied energy, for instance application of the “green concrete”.
- The choice of insulation might compete with the usable floor area, embodied energy content, the cost of investment and finally exploitation costs, thus making it a multi-criterion problem.
- The compact urban form shall not be disadvantageous in terms of natural light provision.
- The strive for the compactness comes into competition with the urban variation and the architecture aiming to break the simplistic box-expression.
- The higher is the degree of buildings insulation, the more adverse are the effect of its discontinuity (i.e. thermal bridges of the balconies)
- Activation of the thermal mass might require specific finishing on certain walls or ceilings. The attention towards the acoustics as well as flexibility of the plan must be drawn.
- Providing the interior common spaces happens at the cost of the individual flats: economically and spatially.
- The economy of land and dense development should be in harmony with the proper dimension of the common public space.
- The economy of electricity and limiting the exterior light pollution shall not compromise the sense of security.

The synergic solutions:

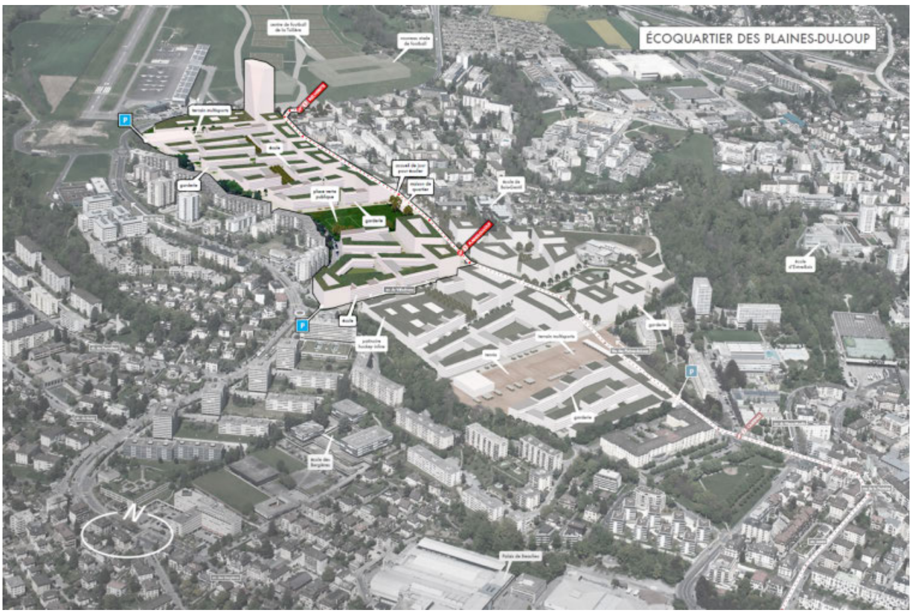
- The compact form allows to reduce the heating/cooling needs and is also efficient in terms of material consumption and related embodied energy.
- The onsite energy production as well as recuperation systems allow for progressively more economic exploitation and little environmental footprint. The application of the heat pumps significantly increases the heating and cooling efficiency.
- The initial overcost due to the technological advancement usually pays-off with lower exploitation fees.
- Energy production in-situ allows to minimise the losses due to the transmission, but is also subject to higher fluctuation of demand than central power plants. The varying yields might be equalized by the public grid handling the surpluses and shortages, allowing to achieve even positive annual balance.
- The anti-seismic wall might be exploited as the thermal mass.
- Dense and diverse neighbourhood might reduce the far distance transportation needs. The correct density justifies and renders the public transportation rentable.
- The moderately dense urbanism protects itself well from excessive solar gains (solar mask of about 22.5°) without compromising the lighting conditions.
- The idea of permeability of the ground surface and water retention ponds considerably improves the ambience of the designed landscape. Its chilling effect, absorption of the rainwaters, as well the related biodiversity are favorable from the environmental point of view.
- The land-consuming water-purification stations can be partly integrated into landscape design, as the phytoepuration process might take place outdoor.
- Solar panels (both photovoltaic and heat collectors), due their technological advancement present big potential of integration into visible elements of the building like the facades- solving the problem of the insulation protective layer. The vertical solar collectors vertical provide lower yield, but more constant one.
- Encouraging the garbage sorting contributes to the closed-loop economy (through the thermal valorisation and recycling, as well as lower land consumption).
- The cooperative model of funding is beneficial from the social point of view, as well as durable conception and exploitation of the building.

Case study: the ecodistrict of the Plaines-du-Loup

The project site is located within future Plaines-du-Loup neighbourhood, a flagship realisation of the city of Lausanne. The idea for an exemplary district is issued from a large municipal project "Métamorphoses", whose main objectives are:

- compatibility with 2000W Society concept
- integration of big equipments into the city.
- development of the city northwards
- implementing a new participative procedure of consultations

The large masterplan comprises three zones playing different roles: Pontaise, Bois Gentil, and finally Plaines-du-Loup where most of the housing will be localised. The quarter is adjacent to the Blécherette Airport, visible in the top-left corner.



56. Plaines-du-Loup, view from south.

<u>Influence on design</u>

The major document providing the base for the project is entitled *“Projet Métamorphose. Concept énergétique pour le quartier durable des Plaines-du-Loup”*. It meticulously presents the indicators and suggestions, which are not, however, binding for the future development. They do however establish a primary reference for the further design, that is subject to certain derogations. The concept of 2000W Society concept assigns a precise quota of energy per branch, but at the same time allows the rule of communicating vessels, as long as overall balance is maintained. It is represented by the following limits:

source of consumption	primary energy	
	houses	offices
construction materials	100	100
interior climate (heating)	45	30
interior climate (ventilation)	25	70
hot water	40	10
lighting+appliances	130	130
mobility	100	140
total (A-value)	**440**	**480**

Apart from A-value, which is the ideal, the B-value is introduced as well. It allows the consumption of energy superior by 25%, on condition that buildings are easily adaptable to value A. The upgrade is achievable providing that building is well insulated from the beginning (Minergie-P standard) and that the heat production is shifted to renewable source.

The following guidelines were also partially issued through the energetic studies supported by the tools of CitySim and SméO, that serve to optimize the projects with the multiple sustainability criteria. The results are divided into two groups, according to the scale of their application: urban and architectural (concerning a single building).

<u>The urban level:</u>

- 30/70 ratio of services to housing floor surface.
- Dense urban morphology (compact forms and contiguous order) is of primary importance. The potential of obtaining heating economies leaves reserve for the wider choice of construction materials and their eventual surplus of embodied energy.
- The urban morphology is prioritized against the orientation of the sample building.
- Embodied energy expressed in construction materials as well as infrastructure is to be reduced in maximum possible extent.
- The advised solar mask is between 20°-25°, therefore results 1:1 proportion of the street to its facades.[27]
- Possible compensation between branches of energy consumption. For instance, if the offices save the electricity, the reserve could be assigned to the housing.
- Solar mask greater than 25° marginalizes the influence of building orientation
- light mobility promotion and its related infrastructure (bike stations, showers etc.)
- reduction of fossil/nuclear generated electricity. Economy of electricity in the nighttime realized with movement detectors and dimming.

[27] Might be greater, then affects geometry of the last floors as e.g. in case of in truncated roofs of BedZed (UK).

<u>The architecture level:</u>

- Analogically, the attention brought to construction materials is crucial for respecting the energy balance.
- The favored building dimensions are of: 5-7 floors, 3000m^2 of gross floor area, the form factor (compactness[28]) lesser than 0.9, the floor area ratio of around 1.8.
- The more the building form is complex, the lower-embodied energy materials should be applied.
- Opting for ⅔ renewable energy share in heat production, for instance: seasonal stockage of solar heat coupled with connection to the thermal power plant fired with at least 85% of garbage. This system is considered compatible with 2000W Society requirements.
- The energy prescriptions per type of space (storage etc.), as well as installations are assumed as fixed, and are provided in the document
- No mechanical cooling (exceptional use only). The cooling shall be provided with passive means, eventually by absorption.
- Certain obligations concerning the water infiltration might be repealed, due to the geologic conditions. It is still advised to keep as much non-hardened, permeable surfaces, as possible.
- Usage of double-flush or no-mix toilets is advised. The waste water residual heat might be recovered.
- The general rule for the windows: 40% of glazed surface towards south, 25% east and west, 10% to the north. Preferably, the east and west opening should be equipped with movable protection to gain the middle-season heat, while avoiding the summer rays. The southern window should be shaded by an immovable element, e.g. balcony, avant toiture, casquette.
- The minimal coefficient of performance of the heat-recovery ventilation: 80%
- Implementation of heat-power generation coupled with heat pump is encouraged for its excellent performance
- No mechanical cooling. In case of housing the passive cooling (thermal mass and nocturnal ventilation) is considered sufficient; eventually might be provided by absorption.

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[28] always expressed as ratio between thermal envelope surface and energy reference area

Further work: project

Apart from technological considerations, it is strongly underlined that architectural diversity is one of the main goals of the future neighbourhood. Therefore certain derogations are possible, and so will be made for the diploma project, which will be conceived in prefabricated concrete. Due to relatively high content of grey energy, this material is not favored in the scale of the neighbourhood, which does not however exclude the punctual application. This decision is taken in order to familiarize with the contemporary construction method, that is currently exploited not only in Switzerland, but also Germany, Netherlands, as well as in the Nordic countries. As a monolithic assemblage of insulation and concrete, the prefabricate possesses strong inherent expression. Despite the bad image associated to the *grands ensembles,* it offers nowadays high potential for elegant architecture due to its somewhat monumental flair.

Further than facade solution and esthetic considerations, the important goal is the optimisation of the windows size in order to resolve the issue of solar heat gains, interior lighting and summer overheating. It is an opportunity to include the knowledge from the fields of specialisation that are sometimes marginalized in the academic projects. Understanding of the energetical repercussions induced by the architectural gestures is the primary reason of this work.

Conclusions

To conclude, it appears that considerable amount of energy might be exchangeable with proper architecture. It might become a new paradigm, taken the growing importance of environmental policies. One of the fundamentals of the modern approach to energy is the concept of Negawatt[29]. It assumes that the otherwise lost fractions of energy (i.e. residual heat) could be exploited and therefore reconstitute a source of primary energy.

Within the pressure put on environmental issue, there is, however, a derogation possible for the buildings of utmost quality and function- as it is not the goal to render everything fit within the same criteria. Contemporary architects would defend building's expression and volume as a factor equally important as e.g. minimizing the content of embodied energy. It is true however that otherwise purely esthetic considerations of proportions or window position will gradually become supported by energetic considerations.

Evidently, the three domains of economy, society and environment are highly interconnected and depending on each other. It is impossible to satisfy all of their requirements in equal measure, therefore priorities must be set depending on project's profile and local capabilities. They can be elaborated through other criteria, than the discussed Recommendations- for instance the Swiss Climate Label audit. In any case these decisions affect the shape of the built matter for a relatively long time; in most cases- longer than expected. Determination of the environment is almost never temporary.

To obtain a full profit from economies and to exert lesser impact on the environment, the users should be sensible and aware of their contribution. Some of the examples have shown that imposing the solutions and assuming certain scenarios might differ from eventual reality. Probably the sustainability will expand as an attitude. The cultural idea of the respect towards environment, is emanating throughout the wealthiest countries of Scandinavia or Switzerland, which also took the role of pioneers. Additionally, this expansion might be also spurred by the idea of introducing it with better quality of life.

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[29] term by Armory Lovins, "the hypothetical unit of saved energy" from:
Hegger, Manfred. *Energy Manual: Sustainable Architecture*. Basel: Birkhäuser, 2008, p. 50

It is partly also a shift towards traditional solutions that has been pushed out by technological advancement since the industrial revolution. Some of the seemingly obsolete techniques like adobe render, timber or solar chimney may gloriously return. Their comeback crystallizes nowadays as a marriage of low- and high-tech, which produces the most spectacular effects, as in case of house in Bennau. The idea of valorising the local and renewable energy is particularly valuable in the world of resource-based politics.

Nevertheless, the built development does not pose an immediate threat to human life, as for example does the transportation. This would explain the abundance of technological means to provide security in modern cars. On the contrary, the buildings have only recently stepped on the road of implementing the electronic systems of management. No matter how advanced seem the contemporary solutions, it is important to know that many of them are known for long. It is only now that mankind is prompted for the change, so it happens with increasing participation and support of electronics. It is almost certain however, that the tendency is not ephemeral, and since the point of no-return has been trespassed- a large part of future development will be shaped in a way that still seems innovative nowadays.

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Annex

The structure of the Recommandation SIA 112/1:

1. Society (Societé)	1.1. Living together (vie en commun)	1.1.1. Integration and coexistence (intégration, mixité)
		1.1.2. Social contacts (contacts sociaux)
		1.1.3. Solidarity and equality (solidarité, justice sociale)
		1.1.4. Participation (participation)
	1.2. Equipment (aménagement)	1.2.1. Identity, sense of belonging (identité au lieu, appartenance)
		1.2.2. Customization (aménagement individuels, personnalisation)
	1.3. Exploitation and viability (exploitation, viabilisation)	1.3.1. Supplies proximity (proximité d'approvisionement)
		1.3.2. Light mobility (mobilité douce)
		1.3.3. Accessibility (accesibilité et utilisabilité par tous)
	1.4. Health and comfort (confort, santé)	1.4.1. Security (securité)
		1.4.2. Air quality (qualité de l'air intérieur)
		1.4.3. Radiation (rayonnements)
		1.4.4. radiation (rayonnements)
		1.4.5. Summer overheating protection (protéction solaire estivale)
		1.4.6. Noise and vibrations (bruit, vibrations)

2. Economy (Economie)	1. Built fabric (substance du bâtiment)	2.1.1. Site (site)
		2.1.2. Built fabric (substance construite)
		2.1.3. Flexibility (structure du bâtiment, aménagements)
	2. Investment costs (frais d'investissement)	2.2.1. Life-cycle cost (coûts et cycle de vie)
		2.2.2. Founding (financement)
		2.2.3. External cost (coût externe)
	3. Exploitation and maintenance costs (frais d'exploitation et d'entretien)	2.3.1. Exploitation and maintenance (exploitation et entretien)
		2.3.2. Renovation (rénovation)
3. Environment (Environnemen	1. Construction materials (materiaux de construction)	3.1.1. Raw materials (disponibilité de matières premières)
		3.1.2. Environmental impacts (impacts environnementaux)
		3.1.3. Pollutants (polluants)
		3.1.4. Deconstruction (déconstruction)
	2. Exploitation energy (énergie d'exploitation)	3.2.1. Heating and cooling (besoin de chaleur ou de froid)
		3.2.2.Hot water heating (besoins d'energie pour la production d'eau chaude)
		3.2.3. Electricity (electricite)
		3.2.4. Operating energy coverage (couverture des besoins en energie d'exploitation)
	3. Landscape (sol, paysage)	3.3.1. Land demand (superficie des terrains)
		3.3.2. Exterior spaces (espaces exterieures)
	4. Infrastructure (infrastructure)	3.4.1. Mobility (mobilité)
		3.4.2. Garbage (déchets d'exploitation)
		3.4.3. Water (eau)

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