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Sustainable Building Envelopes (Ecobuildings, Retrofit, Performance Gap)

eREN Energetic refurbishment – a global approach for the building envelope

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Abstract

Buildings energetic retrofit is key to the Swiss « 2050 Energetic strategy », but the refurbishment rate is low. eREN [1] has analysed the 20th century multi-dwelling housing stock in Western Switzerland from a constructive point of view and developed refurbishment scenarios for the envelope of 10 buildings. The goal is to achieve balanced solutions between energy efficiency, constructive feasibility, building physics, cost, architecture and use value.
Our investigation shows that "wrapping" is not the only solution to meet the standard, whatever the solution it is technically complex, the cost are high but could be mitigated, projects must be led by qualified professionals and interdisciplinarity must be actively promoted.

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Keywords: energetic retrofit, building envelope, global approach, contructive typologies

1. Context

With some 40% of the energy consumption and CO2 emissions, the building sector is a key issue to the "2050 Energetic strategy" of the Swiss government [2]. However, the refurbishment rate is today well below the 2% required to hit the target. Easy measures (replacement of single glazed windows by more performing frames and glazed units) have been carried out on many buildings and the next step will be technically more demanding and may create problems in building physics. Taking into account that financial motivation is too weak at today's energy price to decide owners to undertake energy refurbishment, public authorities develop subsidised incentive programs to switch to renewable energy for heat production and to improve the insulation of the existing buildings. This policy, relayed by insulation producers and energy consultants, has serious consequences. Most interventions consist in wrapping the building with perimeter insulation, with no global overview, bypassing architectural and constructive issues, putting building physics at risk, and slowly but surely changing the image of our urban environment.

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2- eREN origins

eREN is first of all an attempt by architects to regain control on a topic abandoned to energy engineers (many of them lacking of construction background and architectural sensitiveness) and for which insufficient effort has been made in the academic curriculum of architects' training. Our intention is to put back the architectural and social aspects of refurbishment at the centre of the concerns, not the sole energy issue. Building envelope retrofit is necessarily an interdisciplinary issue. It requires a synthetic vision that should be a responsibility taken by the architect. This synthetic vision should aim at weighting interests to find a well-balanced solution between energy savings, constructive and physical issues, architecture, cost, and use value.

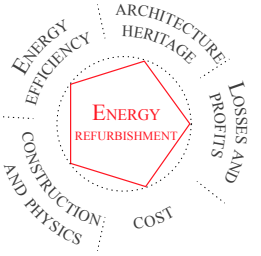

Fig. 1 : Energetic refurbishment criteria

eREN's goal is to search for answers to the four following questions:

- Can we reach the energetic standard (SIA 380/1) [3] without destroying the identity of the building?
- What is the method to achieve such a goal?
- At what cost?
- Is there a link between constructive typologies and refurbishment strategies?

3- Constructive typologies of the existing building stock

Properties with 3 flats and more and 3 levels and more, erected after 1900 and before the first energy standards of the 1980s form some 80% of the pre-1990 building stock in Western Switzerland [3], forming the sample with the highest potential for energy saving. An inventory of the most recurrent constructive typologies of this sample was done based on 193 buildings in Geneva, Vaud and Fribourg. This analysis was carried out on 8 key elements to establish the dominant constructive typologies across time:

1. Flooring against unheated spaces
2. Flooring between heated spaces
3. Façade walls
4. Roof
5. Windows
6. Window jambs
7. Solar protections
8. Balconies

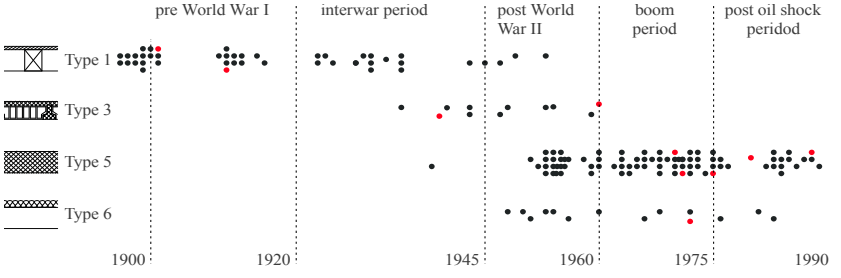

Fig. 2 : Building distribution : flooring between heated spaces (example)

Out of the analysis of the 193 buildings, 5 major periods (Pre-war : 1900 – 1920, Interwar . 1921 – 1945, Post-war : 1946 – 1960, Boom years :1960 – 1975, Post oil shock :1976 – 1990) and 15 constructive typologies have emerged.

Fig. 3: Typology models

4- Case studies

10 buildings, characteristic of the more common typologies, were selected as study cases. Original drawings, on site surveys and measurements of U values, etc. were confronted to establish a realistic view of the construction details and performance of each building envelope. A refurbishment strategy was then chosen for each building: Maintain the typical features / Rebuild the typical features / Add new features or change the image of the envelope.

Calculations of the actual thermal performance according to SIA 380/1 were carried out and compared to the energy consumptions extracted from the available data (energy bills or the Heating requirement index "IDC"). Discrepancies above 20% (which was set as an acceptable gap) could be explained by user impacts, air infiltration rates, U Values of construction elements, etc. Refurbishment scenarios were then developed for each study case responding to the chosen strategy and checked against the requirement set by SIA 380/1 (global thermal balance sheet). The scenarios have gone through an iterative process between the team's architects and engineers which eventually resulted in compromises satisfying in every instance both the energy requirements and the other criteria.

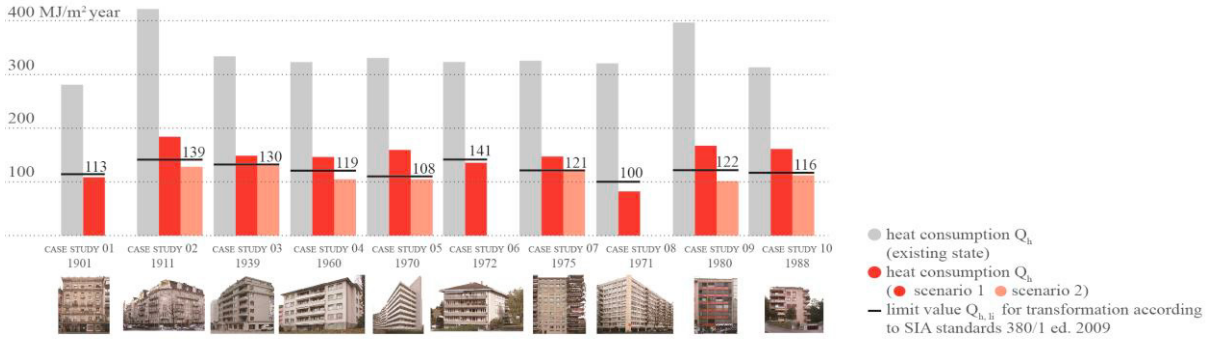

Fig. 4 : Existing state and scenario heat demand for heating

Sheets summarising the scenario that complies with the SIA 380/1 standard, showing construction details, thermal and financial results and an assessment of the impacts on the other criteria, were elaborated for each building.

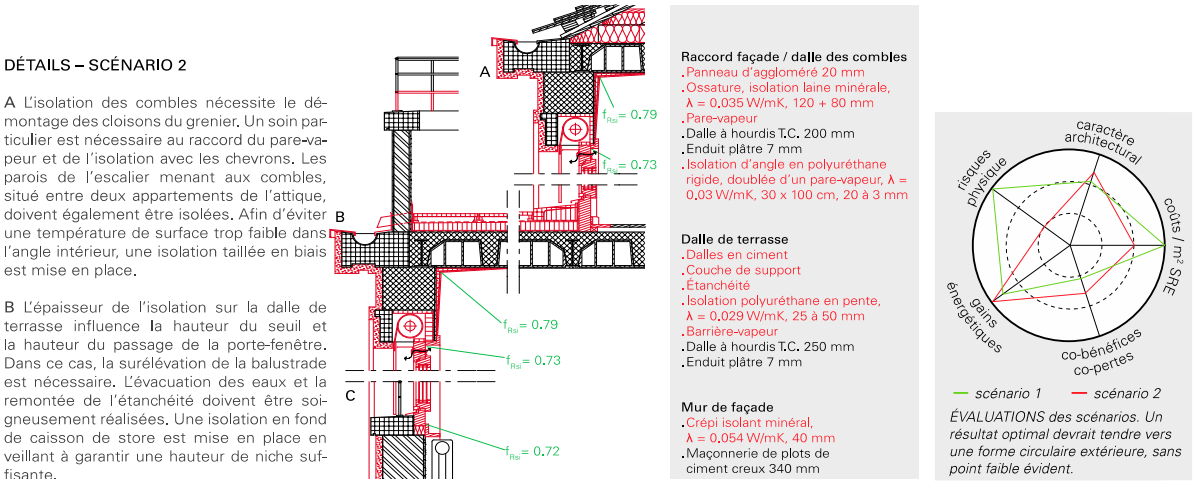

Fig. 5 : Illustration : extract of a case study building sheet with criteria radar (only available in French)

5- eREN teachings

Can we reach the energetic standard (SIA 380/1) without destroying the identity of the building ?

In all cases a scenario that meets the energy standards was achieved, respecting the architectural substance and identifying the critic details in term of building physics. What is qualified as a valuable architectural feature worth maintaining or not was left to the authors' appreciation. It is therefore subject to discussion and to evolve in time.

Alternatives to wrapping are possible, but difficult. First, because care for banal architecture, seen as a heritage component of the urban fabric is restricted to the circle of architects and historians. Energy public services and specialists are less aware of the issue and naturally promote solutions to maximise the energy gain, often incompatible with a respectful approach of the building characteristics and history. For instance: the Programme Bâtiment (Building programme) in canton de Vaud [5] subsidises envelopes refurbishments that comply with a punctual U value of 0.2w/m2k on at least 90% of the surface of the external envelope. All eREN scenarios meet the legal energy saving target, but only 5 of them would be eligible for subsidies.

Second, the complexity of refurbishment is under estimated. Regulation has been developed for new constructions and does not take into account the specificities and limits of existing buildings. Everyone understands that bringing a 1950 car to the fuel consumption, safety and comfort standards of 2017 is an illusion. Why is this not equally true for buildings? In the majority of existing buildings, insulation thickness will be at some point limited by floor heights, property boundaries, balcony deepness or minimum room surface. Thermal bridges, internal insulation (vapour barrier integrity), treatment of blind boxes and of embrasures, existing pipes to the underside of slabs, are all issues that the "red line strategy", reducing the design work to a coloured line drawn around the building envelope (Fig. 6), totally misses. The resolution of details and their implementation requires a lot of care and good results will only be reached using qualified design teams and contractors.

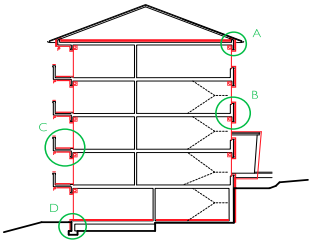

Fig. 6 : schematic sections, red line strategy

As interventions on existing buildings represent a growing percentage of the market, it is time for architects to take interest in those projects and to regain control of the process. Or to accept that our cities will undergo a deep impoverishment of their identities because the field is left to energy engineers unaware of the issue. It is also time for the prescribers to understand that the strengths and weaknesses of existing buildings should be considered when it comes to energy savings and elaboration of standards, because placing the bar too high will be counterproductive.

What is the method to achieve such goal?

The goal could be achieved only through interdisciplinarity and much iteration. We believe in this method, but our experience during the project proves that it is difficult to achieve, due to geographic distance, misunderstandings, etc. Coordination of the team should be the role of the architect, as long as he/she has interest and competences in all concerned fields. He/she has a responsibility to integrate energy concerns at the very beginning of the process and to follow it through the construction phase and commissioning.

Interdisciplinarity will remain an illusion if qualified professionals are not available. Should a real boost be given to energetic retrofit, the market would not cope, due to the lack of qualified architects, engineers and contractors.

It is the professional schools' and universities' duty to propose training in the field, much more than today, where teaching programmes are greatly oriented towards new constructions. eREN has the ambition of giving some best practices advice and is currently used in Western Switzerland as a tool for professional training.

At what cost?

Energetic refurbishment is expansive and its profitability is questioned at today's energy price, especially since the reduction of heating cost benefits only the tenants and since rents can be increased taking into account only a fraction of the cost of refurbishment (OBLF, art. 14 [6], with some cantons, like Geneva, even more restrictive). The total amount of each scenario was weighted to represent only the costs directly related to energy saving measures (the weighting technique was developed in house, as no recognized method for such allocation exists in Switzerland). No subsidies were taken into account (subsidies differ from one canton to another).

On average, the depreciation period of work in the 10 study cases is 90 years, far more than the life expectancy of any of the implemented solutions. Subsidies would improve the financial result but would not compensate the whole gap. The motivation for energetic refurbishment finds its roots in legal requirements, obsolescence, opportunities (increased market value or rental surface) or in the owner's "eco-consciousness", but not in profitability.

The comparison of cost and thermal performance of the scenarios presents a contrasted picture. In 50% of the cases where more than one scenario had to be developed, the first scenario already reaches some 80% of the required saving, at reasonable expense. The last 20% imply a large increase of the cost (Fig.7), of the complexity of the constructive details and of the impact on the apartments' occupants. In other words, a sound proportion of the refurbishment projects that would already greatly mitigate buildings'energy consumption might not be launched because the financial, technical and social effort to gain the last MJ to hit the standard is too high. Doing nothing would be the most reasonable approach. And to those tempted by a State coercive approach, the Swiss voters, in majority liberal, would, in our opinion, promptly give a disappointing answer.

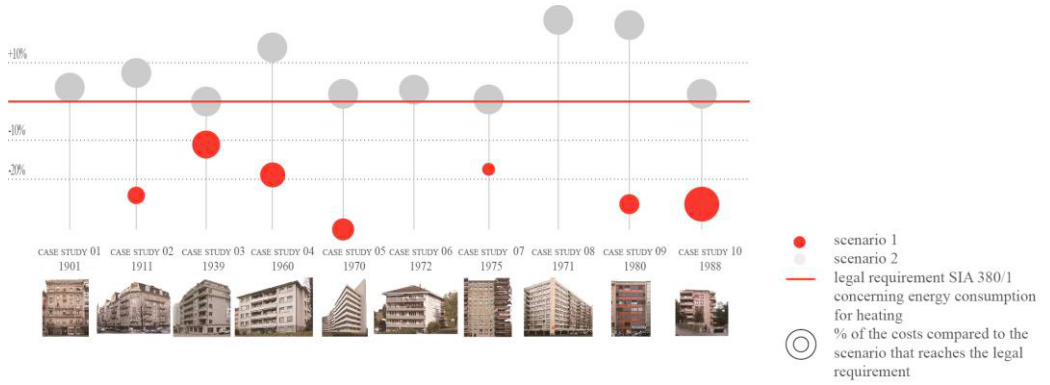

Fig. 7 : scenarios cost comparison

Amongst the results of eREN was the finding that for two of the study cases, where perimeter insulation wrapping was priced in a parallel study, the cost difference was contained within very reasonable limits (-2% to + 14%). A complementary study to give more robustness to this hypothesis has been ordered in 2016 by the CRDE (Conference Romande des Délégué à l'Energie) and the preliminary results are encouraging for the alternatives to "wrapping".

Is there a link between constructive typologies and refurbishment strategies?

Obviously there is a link between constructive typology and retrofit strategy. An early 20th century building with a rich decorated stone façade will accept nothing else but internal insulation. However, it is impossible to claim that a specific typology is fitter for refurbishment than the others. They all have their strengths and weaknesses. Buildings of the 60s, of large dimension and repetitive, offer opportunities for standardisation and rationalisation of the details. But the presence of linear balconies with concrete slabs protruding causes serious thermal bridge issues. It appears that targeting a specific typology because it would be easier to treat than another one is not a starting point.

As often, the right pathway is likely to be found in the middle way, where potential for energy saving, easiness of constructive details, building physics, architecture preservation and use value offer the best compromise (see Fig. 5, eREN radar). This approach implies an individual analysis of each building by qualified people, sometimes based on several scenarios, simply because alike human beings, buildings can belong to the same family, but they will always show differences and demand an individual treatment.

6- eREN follow up

Two projects, already mentioned above, with completion due in summer 2017 (still undergoing at the date of writing this article) have emerged out of eREN: eREN-2, based on the same study cases aims at determining the potential for expansion of the buildings rental surfaces (vertical or horizontal expansion) and its impact on the profitability of the refurbishment process. eREN-C, again based on the same building sample, proposes a comparison between the eREN scenarios and a standard "wrapping" solution, in terms of cost, architectural impact, building physics, details and use value. Their outcomes will be presented in due course.

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