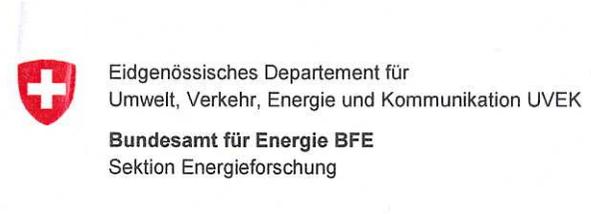


Renovation of Historic, Protected Buildings in Geneva

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Foreword

The objective of SHC task 37 is to “develop a solid knowledge base on how to renovate housings to a very high energy standard and to develop strategies that support the market penetration of such renovations”.

Renovation of existing buildings is the major potential to implement energy saving and reducing energy consumption (new buildings represent only 1 to 2% of the built environment per year). But in order to achieve high energy standards it implies heavy renovation with important interventions on the envelop.

But for protected buildings of architectural quality and historical importance (that represent, for example, over 30% of Geneva’s built environment), heavy renovations are difficult and often questionable. In case of renovation, contradictory requirements occur between patrimonial commissions (concerned with the preservation of the architectural heritage) and energy offices (with the mission to apply the law and drastically lower energy demand).

The purpose of this project is to help architects, energy and patrimonial commissions to achieve thermal renovation of buildings with architectural and historical value by:

- Showing exemplary achievements.
- Describing technical solutions and building details of a selected range of projects.
- Exploring the limits of possible thermal improvements for various kinds of buildings.

Introduction

PROTECTED BUILDINGS OF HISTORICAL VALUE

ZONES

In the frame of the Federal law of town and country planning assessing the necessity to protect zones and objects, the legislation is up to each canton who have their own law on monuments, nature and sites' protection.

Example of Geneva

The example of Geneva is relevant for Switzerland with all kinds of protected constructions including also modern buildings. Protection includes:

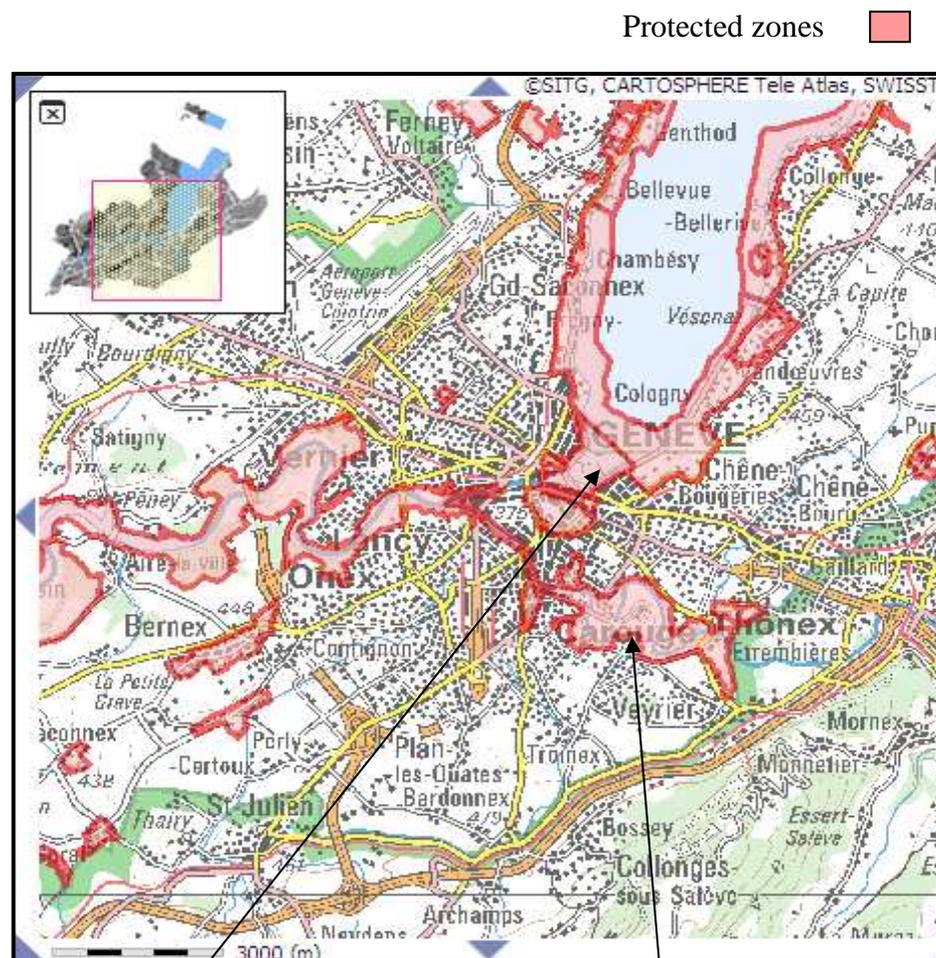
- Protected zones
- Listed buildings
- Inventory

Protected zones

They are defined in articles 28 and 29 of the Application Law of the Federal Law on Regional Planning (LaLAT).

The protected zones are the following:

- the area of the Old City of Geneva and the southern sector of the ancient fortifications
- the area of Old Carouge
- the protected villages
- built areas of the nineteenth and twentieth centuries
- the site of the Rhone, according to the Law on general protection of the Rhone banks, January 27, 1989
- the lake shores, according to the Law on general protection of the lake shores, December 4, 1992
- the banks of the Arve, according to the Law on general protection and rehabilitation of the Arve banks, May 4, 1995.



Old Town of Geneva

Town of Carouge

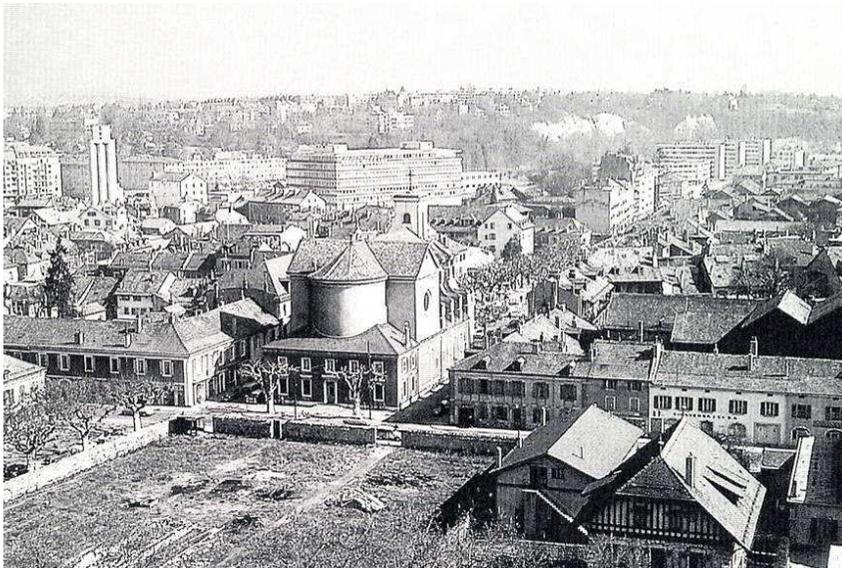
1. Introduction

PROTECTED BUILDINGS OF HISTORICAL VALUE / ZONES

Old town of Carouge



Old Town of Geneva



PROTECTED BUILDINGS OF HISTORICAL VALUE / LISTED OBJECTS

Classified Objects

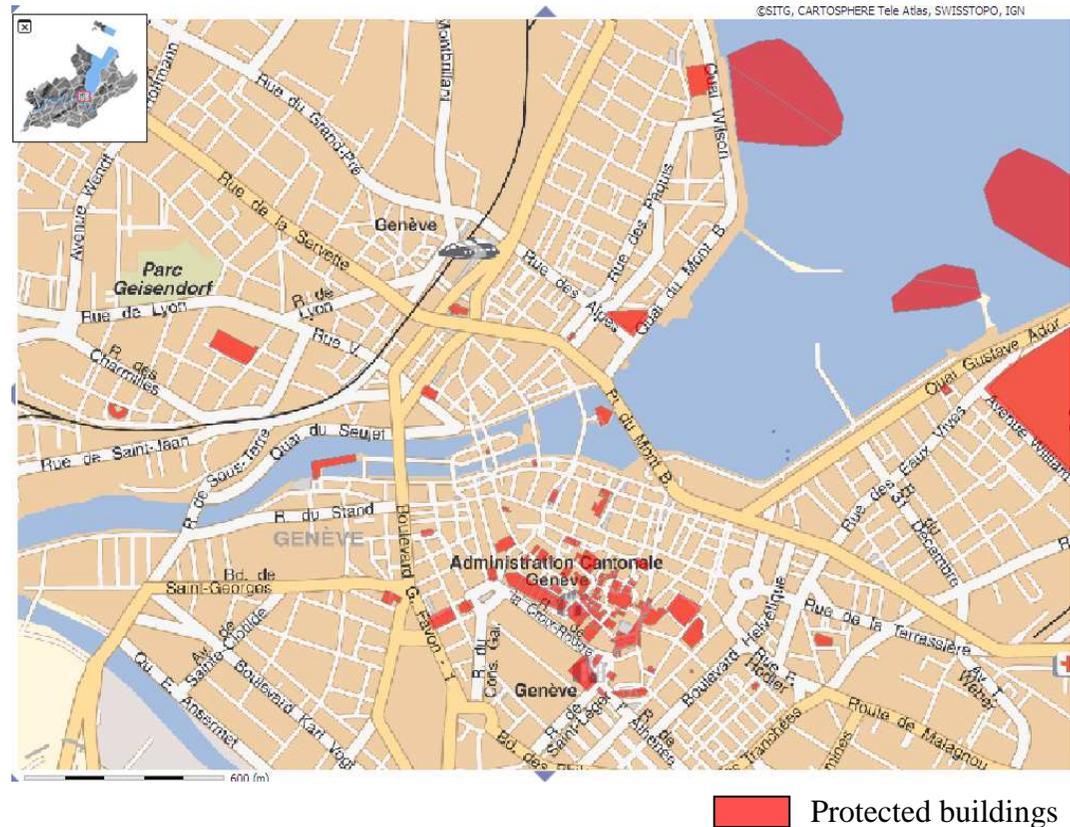
“Section 3. Classification, art 10” Decree

In order to insure the protection of monuments, the local authorities have the ability to classify them by decree, assorted if necessary with an appropriate plan.

The classification of buildings and sites regarded as remarkable and worth to be protected constitutes the oldest safeguard measure for Geneva, that came into effect simultaneously with the first law of protection of monuments and sites in 1920.

It concerns more than 300 buildings.

Originally the classification especially aimed at churches, castles, urban and country houses, fountains and also archaeological sites. Today the protection also includes industrial inheritance, as well as built objects from the 19th and 20th and centuries.



PROTECTED BUILDINGS OF HISTORICAL VALUE / INVENTORY

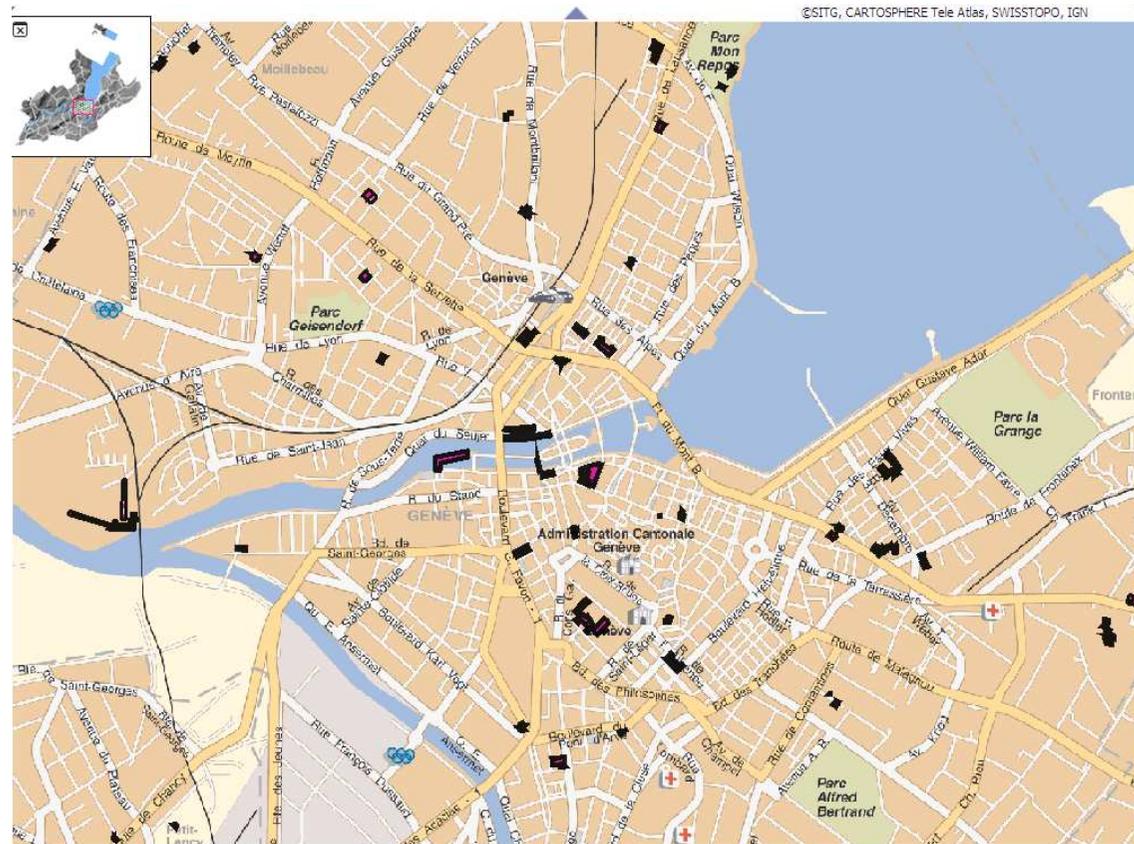
Inventory of buildings of historical value

Section2 Inventory Art

An inventory of all the buildings worth to be protected according to the meaning of article 4 is drawn up.

For many years, the authorities in charge of the protection of the architectural heritage in Switzerland and abroad have established an inventory, i.e. a repertory of the buildings and objects recognized as being of interest. This repertory undergoes permanent updates. It points out a relatively high number of buildings or interesting objects going back to various periods, including the 19th and 20th centuries.

In Geneva, the inventory refers to valuable buildings and monuments of historical, artistic, architectural or educational value and which, for this reason, deserve to be protected.



Down-town, situation of buildings listed in the Inventory

Typologies of walls

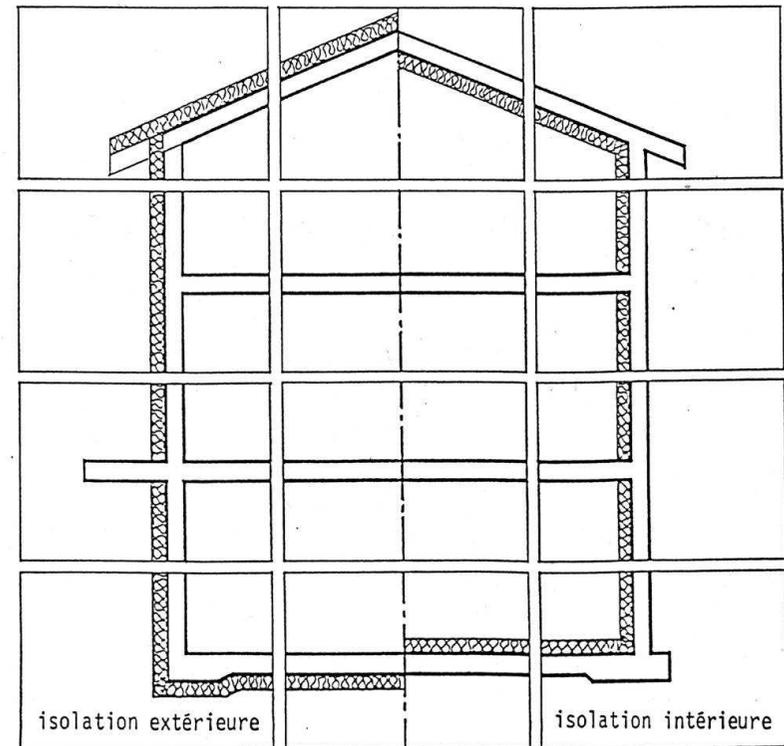
Typology of walls / Choice of examples

POSITIONING OF THE INSULATION

For thermal renovation of protected buildings, the interventions on the walls of the thermal envelop and the windows are delicate and are most of the time limiting factors. If up to this day the glazing have been the subjects of many studies and benefit from a range of technical solutions and available components, it is not the same for the thermal improvement of the walls. The difficulty which inevitably arises is how to integrate insulation in a classified building. Except monolithic walls there are two main solutions :

- *Internal insulation, not optimal because of the ruptures of the continuity of the insulation at each concrete slab or partition wall, causing cold bridges;*
- *External insulation, a solution that ensures the continuity of the insulation and offers optimal insulation, but affects the external appearance of the buildings.*

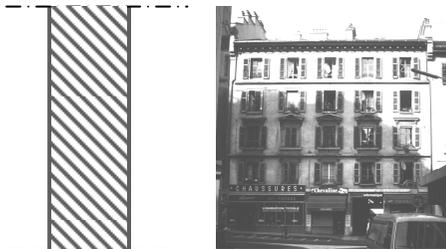
To classify buildings by typology may help to find clever solutions able to be applied for renovation. Therefore, in this research, we will try to classify the buildings' envelopes in relation with the structure and the position of the insulation.



TYPLOGIE OF WALLS TO RENOVATE

Walls from old buildings are often homogeneous and act at the same time as thermal insulation and structure. In farms and castles the massive stone walls used to be covered with wood to insure a better thermal comfort. In the middle of last century, buildings were insulated with double brick walls. External insulation appeared only during the 80's, with different types of claddings. Light façades or curtain walls have been in use since the 60's as filling between walls and slabs or as a continuous wall covering the façade.

Monolithic and internal



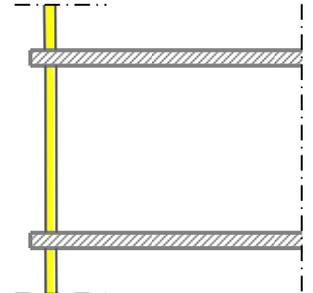
Monolithic

External insulation

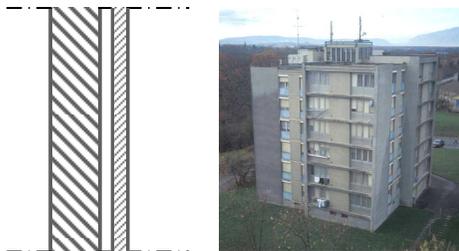


Insulating stucco

Curtain wall



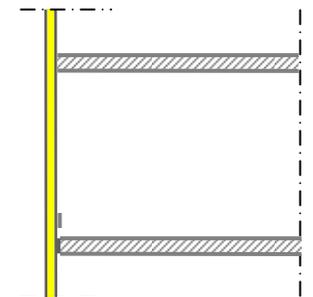
Interrupted (by floors slabs/walls)



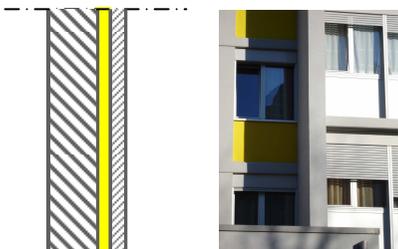
Cavity insulation



Stucco over insulation



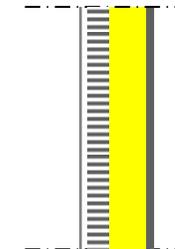
Continuous (over floor slabs)



Interior insulation

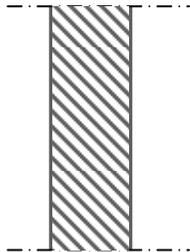


Cladding over insulation



Light façades

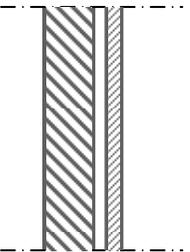
TYOLOGIE / CHOICE OF EXAMPLES



Monolithic



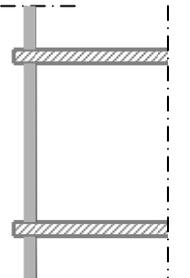
Type 1
20, rue des Grottes
Building 1870
Renovation 2002



Internal doubling



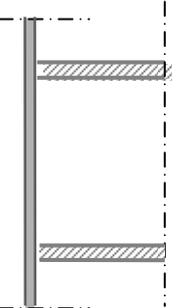
Type 2
Cayla towers
Building 1954
Renovation 2002



Filling between walls and slabs



Type 3
Boulevard Carl-Vogt
Building 1962
Renovation in preparation



Curtain wall covering walls and slabs



Type 4
Cité du Lignon
Building 1964-67
Renovation 2010

Selection of buildings

A selection of buildings illustrates this study based on the following criteria:

- Buildings listed for patrimonial value,
- Buildings representing different periods and different types,
- Participation of the CUEPE at some stage of the project (For the City of Lignon and Cayla, participation in the mediation between the Cantonal Office of Monuments and Sites, the Cantonal Service for Energy and the owners).
- Availability of technical data and records of energy consumption.

3. Type 1 / Apartment building 20, rue des Grottes
Wall type: Monolithic



3. Type 1 / Apartment building 20, rue des Grottes

SUMMARY

The buildings 18 to 22 rue des Grottes are part of a 1870's development of low standard apartments for workers.

The City of Geneva, owner of these buildings, decided, under pressure of the inhabitants, to make an exemplar renovation, renouncing to demolish the buildings. While preserving architectural qualities, this renovation also tried to achieve a drastic lowering of energy demand:

Insulation of the envelop, double flux ventilation, central gas heating and solar panels for hot water.

All along this work, the contribution of energy saving has been defined by simulations and evaluated for each intervention.

Owner	Ville de Genève
Architects	Grand, Praplan & Associés
Renovation	2002 -2005
Built volume	10940 m ³
Number of apartments	21
Costs	7 200 000 Frs.
Energy index	
• before renovation	181 kWh/m ² an
• after renovation	106 kWh/m ² an

Description

Insulation over basement and over top floor. Insulating rendering on the outer side of the walls. Internal insulation of the walls in the last floor. New windows. Central heating with gas installed under the roof. Double flux ventilation.

Information sources:

Town of Geneva, Service des bâtiments, Service de l'énergie, leaflet Ville de Genève 2005.



3. Type 1 / Apartment building 20, rue des Grottes

SIMULATION

Consumption before renovation has been evaluated by the “Service de l’énergie” of the Town of Geneva to 181 kWh/m²year

Energy consumption after renovation, as measured by the same Service, is of 106 kWh/m²year, including hot water.

In order to understand the improvements resulting from each intervention, a series of simulations will allow to evaluate their effects:

- Before renovation
- Insulation of roof and ground floor
- New windows
- External insulating rendering and internal insulation of the wall of the last floor
- Heat recovery ventilation.

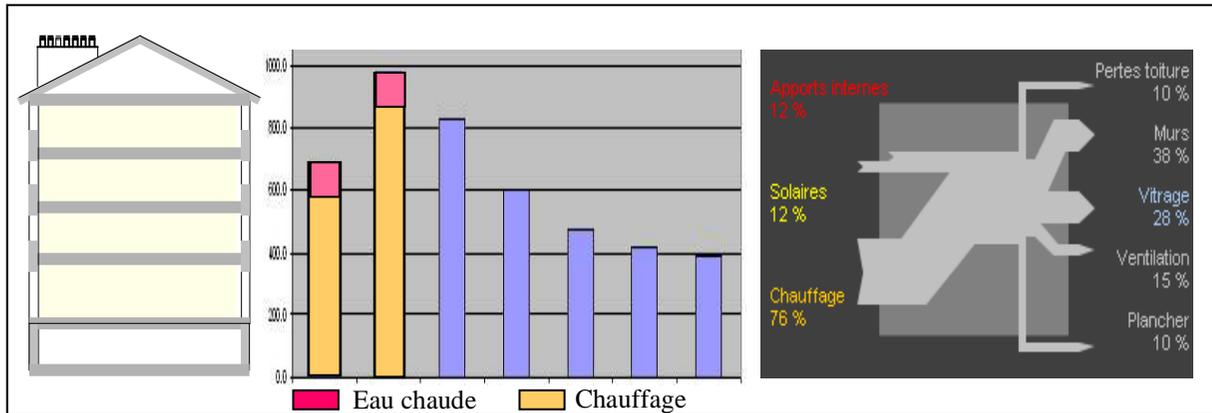
To compare these figures with other buildings, the consumptions are given in m² of heated floor, calculated outside the walls.



South-east facade / 20-22, rue des Grottes

3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT



Building before renovation

This apartment building dating from 1870, representative of low standard buildings of this period, is only 11 meters wide. It has a simple façade without decoration and windows covering 20% of the façade.

Construction:

Stone walls with lime mortar

Single glazed wooden frame windows, window embrasures out of limestone

Cold roof covered with flat tiles

Ground floor with arcades over the basement

Energy index before renovation and new central heating is evaluated at 650 MJ/m²year by the « Service de l'énergie » of the Town.

Terms of use:

Internal temperature 18 °C (without central heating)

Internal temperature 22°C (in order to compare with actual standard)

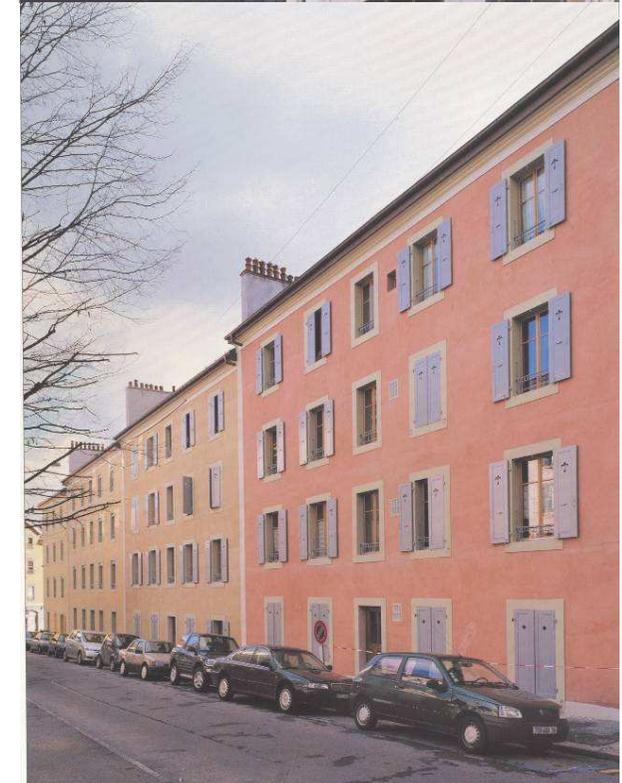
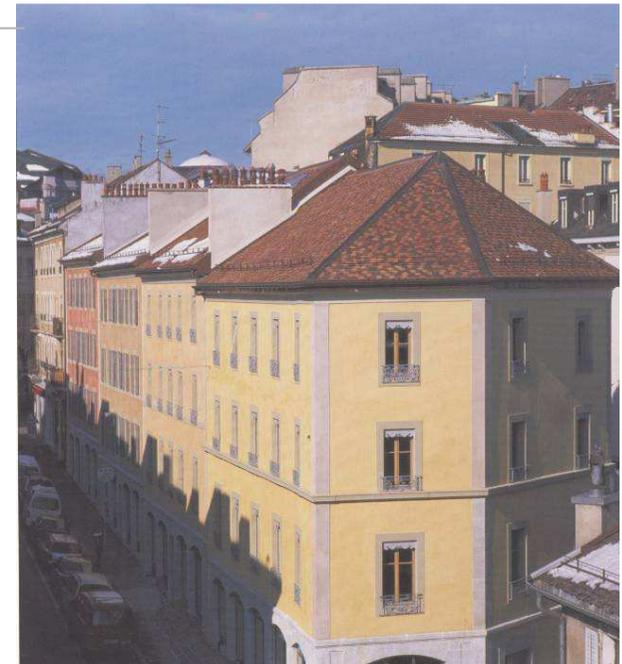
Hot water 123 MJ/m²an

Hourly supply air flow rates 1 m³/m²

Boiler Performance 95%

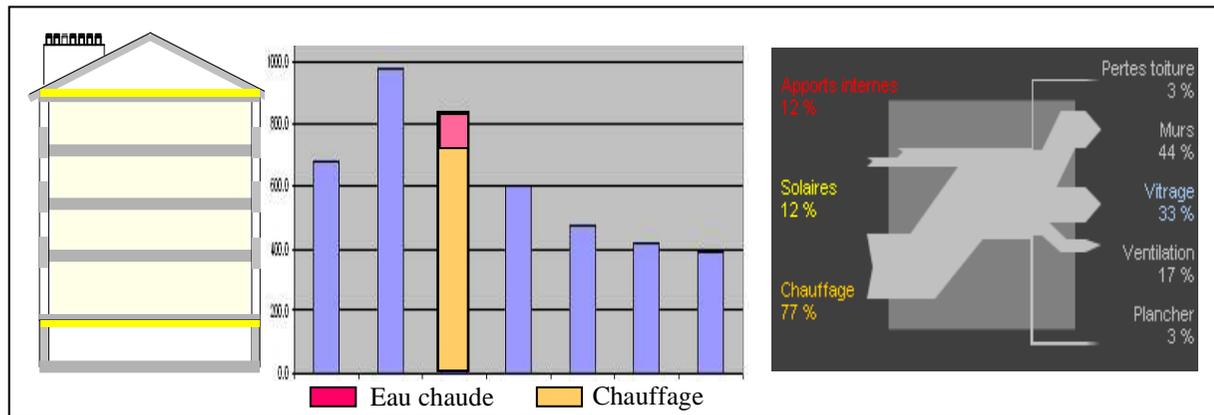
Energy index, simulation with 18°C (before central heating) 187 kWh/m²an

Energy index, simulation with 22°C (actual standard) 272 kWh/m²an



3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT



Improvements

Insulation over basement (U -value, W/m^2K , before 1.97, after 0.3)

Insulation over top floor (U -value, W/m^2K , before 1.28, after 0.23).

Terms of use

Internal temperature $22^\circ C$ (comfort temperature generally measured in apartments)

Hot water $34 kWh/m^2an$

Hourly supply air flow-rates $1 m^3/m^2$

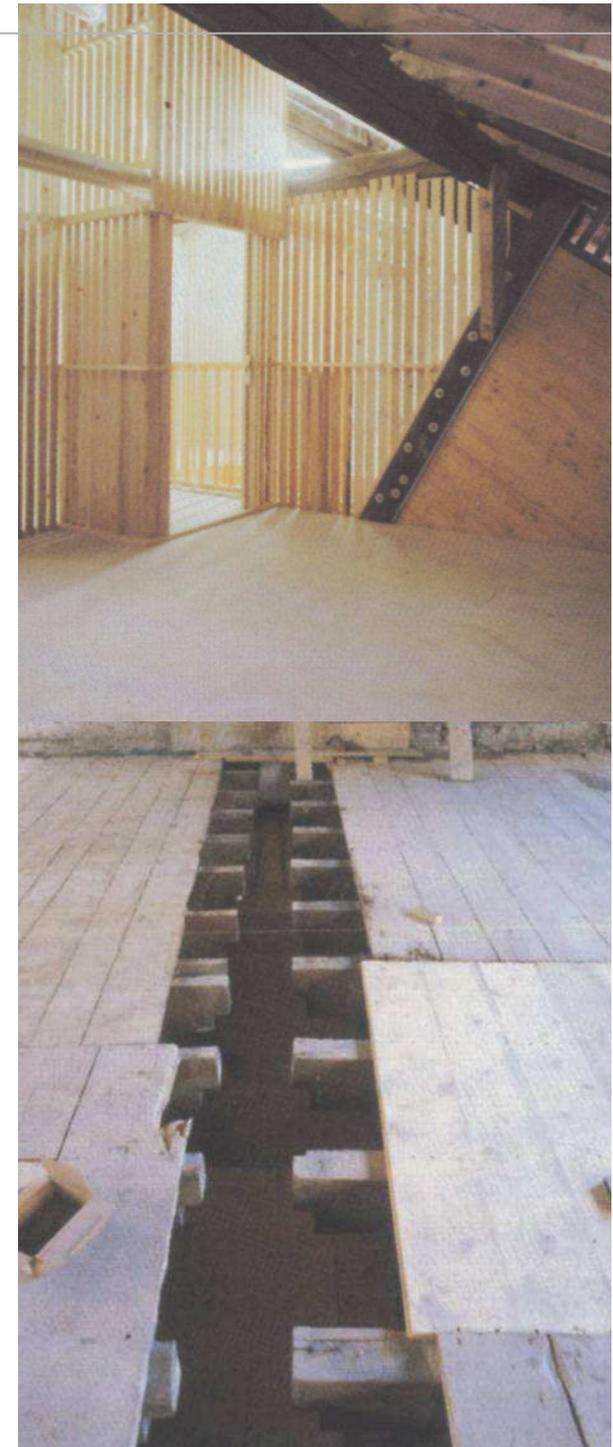
Energy

Heating $193 kWh/m^2an$

Energy index, heating + hot water $230 kWh/m^2an$

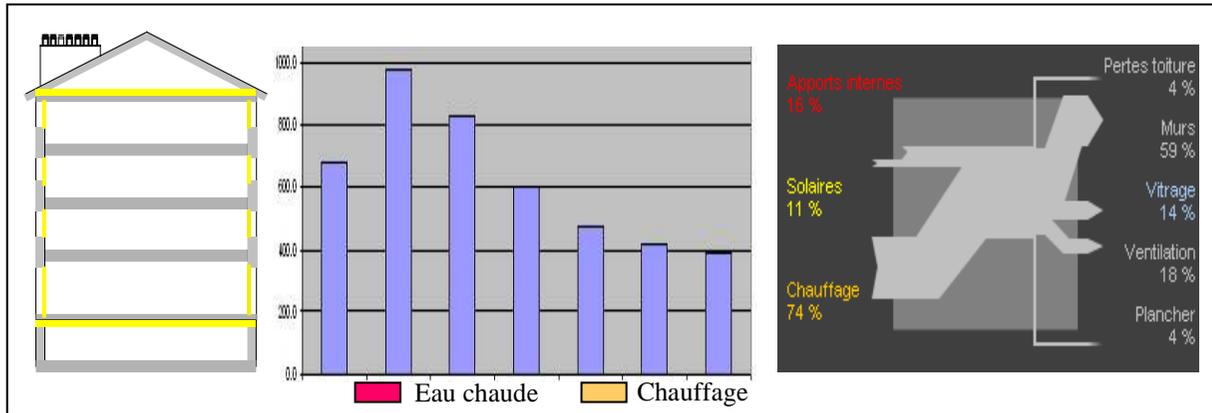
Savings

$42 kWh/m^2an$



3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT



Improvements

Replacement of single glazed windows keeping the original window outline (« modénature »), the original material (wood) and the window embrasures out of limestone. U-values (W/m²K) of Glazing, before 5.5 after 1.4.

For the arcades, steel frames avoiding thermal bridges. Glazing with U 1.4 W/m²K. With new frames you improve air tightness causing lowering of air infiltration and reducing heat losses.

Terms of use

Internal temperature	22°C
Hot water	34 kWh/m ² an
Hourly supply air flow-rates	0.8 m ³ /m ²

Energy

Heating	130 kWh/m ² an
Energy index, heating + hot water	167 kWh/m ² an

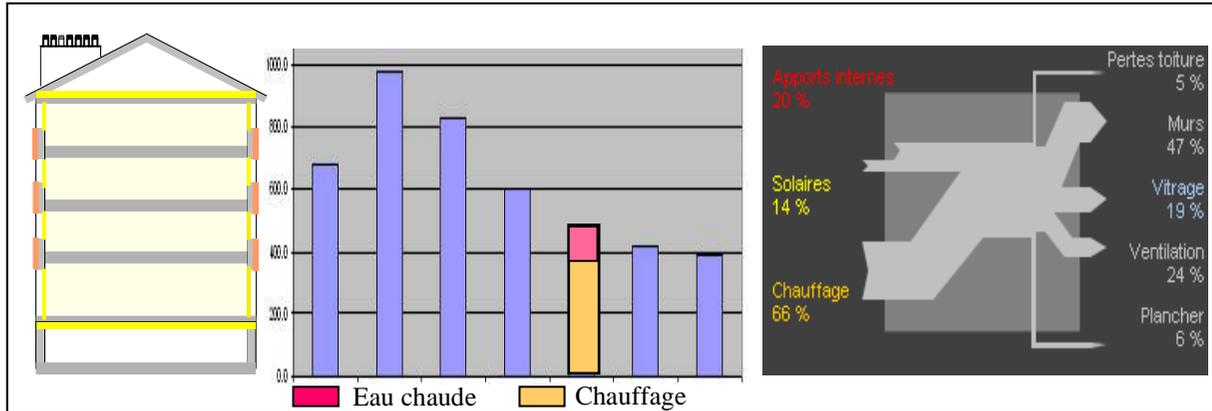
Savings

63 kWh/m²an



3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT



Improvements

Insulating stucco ($\lambda = 0.66 \text{ W/mK}$). U value of the wall ($\text{W/m}^2\text{K}$) before 1.94, after 1.09.

For the arcades: steel frames without thermal bridges. Internal insulation of the walls of the last floor, becoming thinner.

Terms of use

Internal temperature 22°C
Hot water $34 \text{ kWh/m}^2\text{an}$
Hourly supply air flow-rates $0.8 \text{ m}^3/\text{m}^2$

Energy

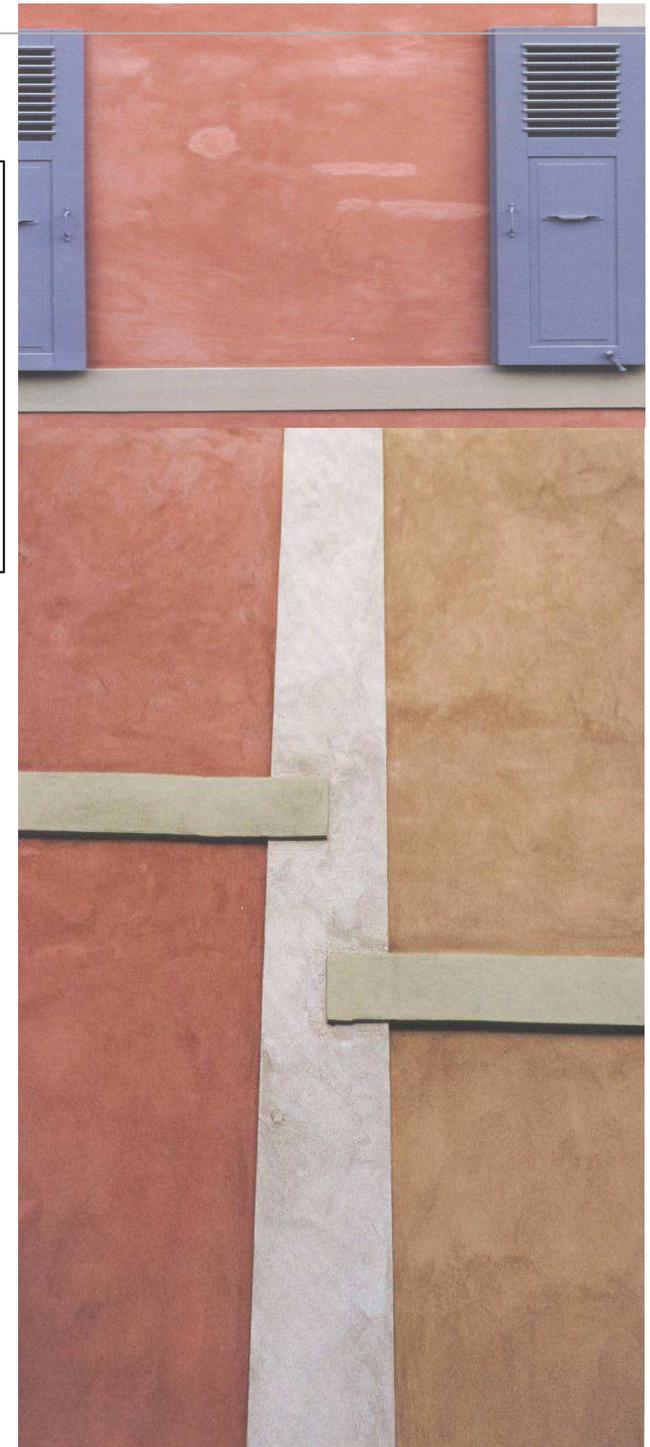
Heating $95 \text{ kWh/m}^2\text{an}$
Energy index, heating + hot water $133 \text{ kWh/m}^2\text{an}$

Savings

$35 \text{ kWh/m}^2\text{an}$

Limiting factor

In case of internal insulation of the walls, there are risks of air infiltrations and moisture on the beams head



3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT

Risk of moisture of the head of the wooden beams

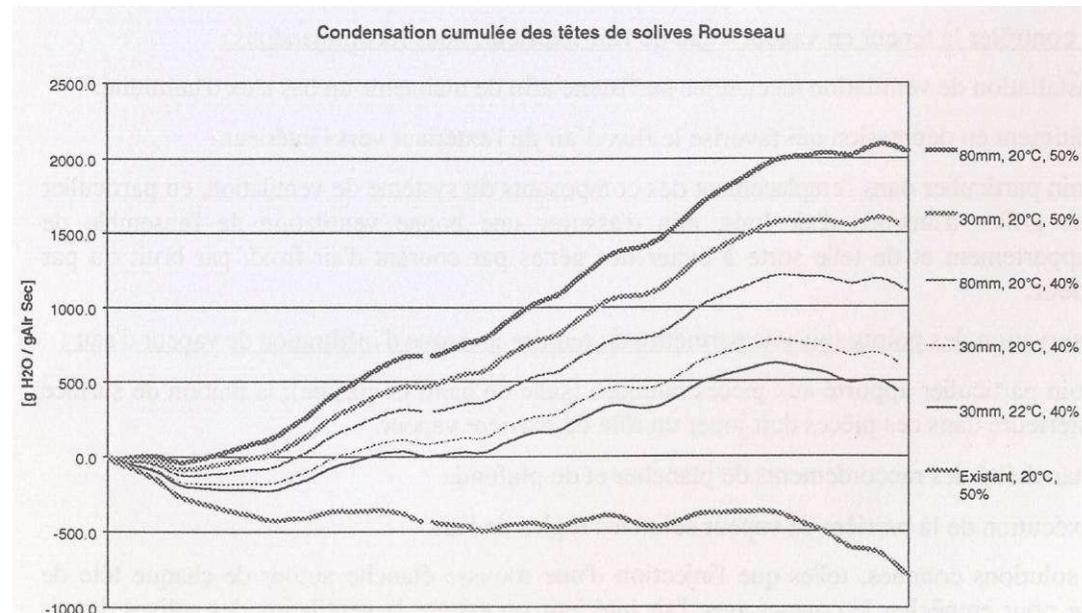
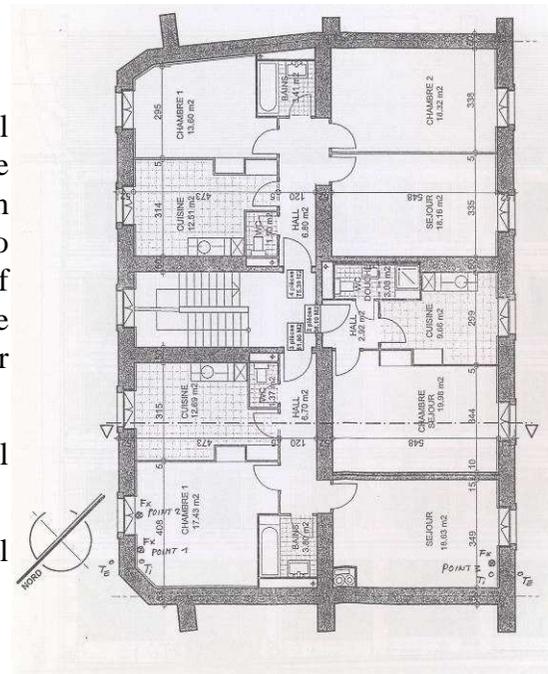
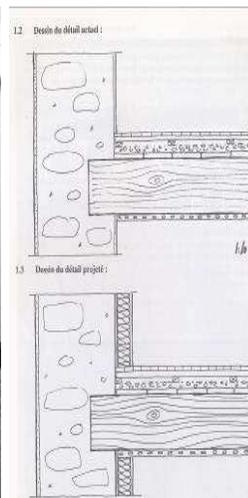
For buildings with wooden floors, in case of internal insulation of the walls, there are risks of moisture on the beams head that may cause structural problems. A research undertaken for the town of Geneva, who was planning to renovate another block of buildings, allowed, with means of simulations, to evaluate the accumulation of humidity on the head of the beams for different thicknesses of insulation. Over 30 mm of insulation, special precautions have to be taken.

Solution 1. Insulating stucco on the outer side of the wall will raise temperature of the wall and lower risk of moisture.

Solution 2. Ventilate the head of beams from outside (drill holes)

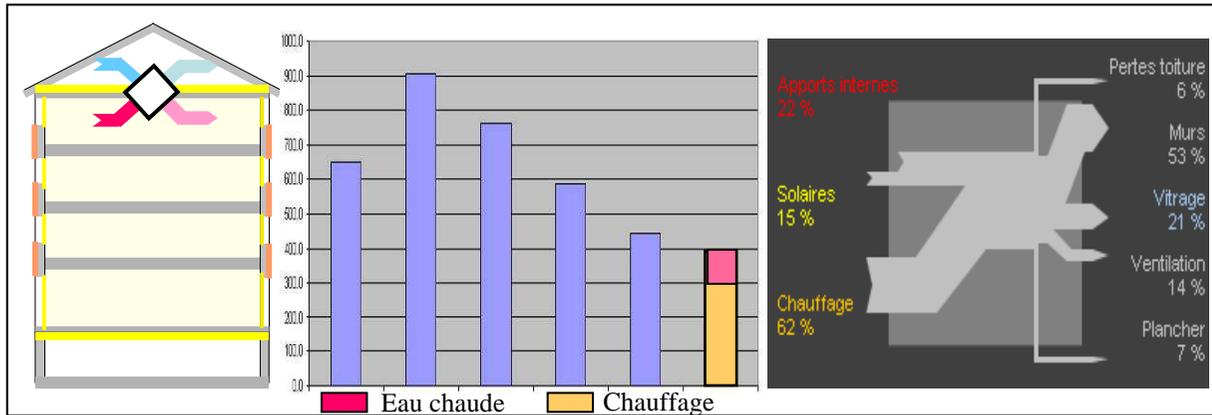
Risk of moisture on the head of the beams.

Dynamic study of the thermal behaviour of the walls of the building at rue Rousseau, CUEPE, 1997



3. Type 1 / Apartment building 20, rue des Grottes

RENOVATION AND THERMAL IMPROVEMENT



Improvements

Double flux ventilation¹ of 0.7 m³/m²h, with heat recovering is placed in the attic with a performance of 50%.

35 m² of solar panels, installed in the roof, are preheating hot water for around 40 inhabitants, saving 25% of the related energy (measured). Tanks of 2000 liters are located on the top floor

Terms of use

Internal temperature	22°C
Hot water	34 kWh/m ² year
Hourly supply air flow-rates	0.8 m ³ /m ²

Energy

Heating	79 kWh/m ² year
Energy index, heating + hot water	117 kWh/m ² year

Savings

15 kWh/m²year

Solar panels for hot water

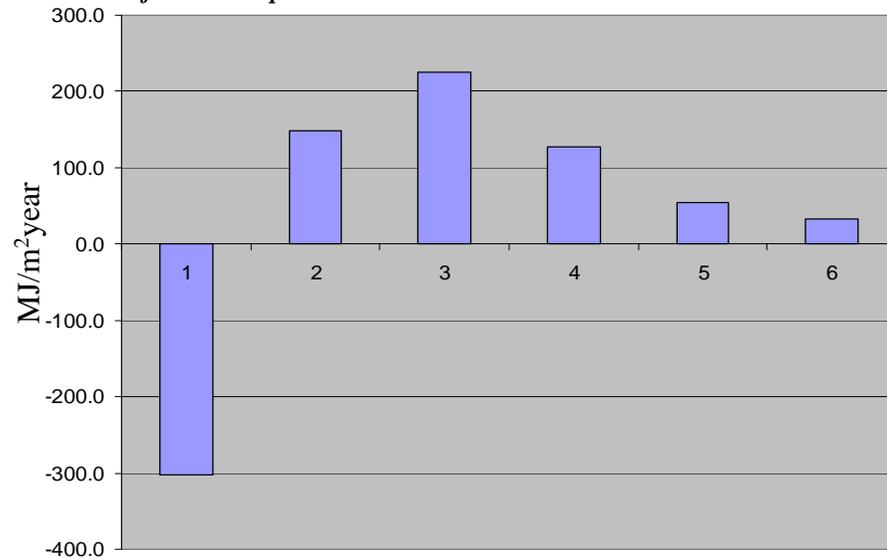
Savings	9 Wh/m ² year
Final energy index	106 Wh/m ² year

1. Double flux ventilation brings fresh air in the rooms, this air is preheated by the extracted hot air.

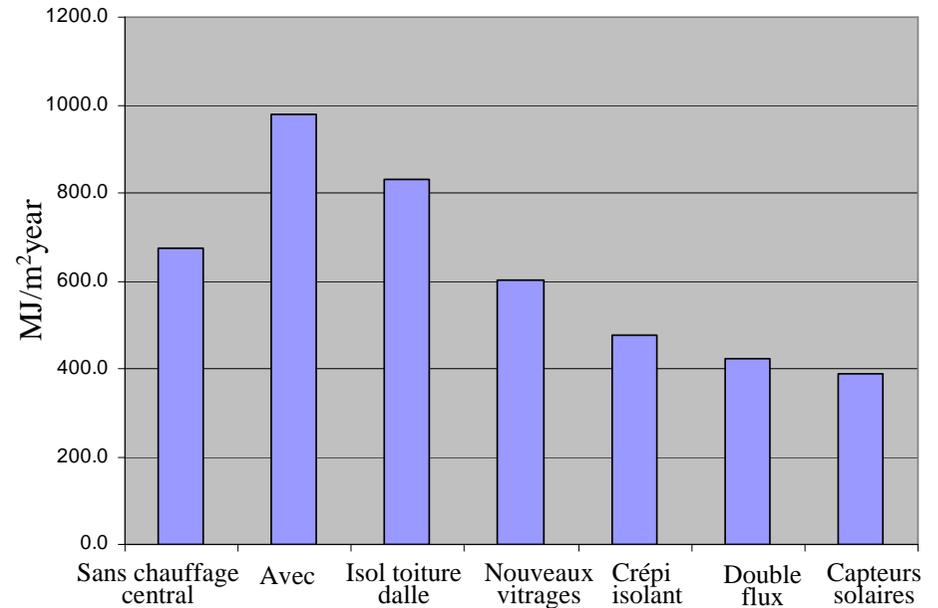


EFFECT OF IMPROVEMENTS

Comparison between the energy savings of the various improvements of the envelop.



Energy consumption at the various stages of the improvement.



- 1) The change in thermal comfort, with the shifting of air temperature from 18°C to 22°C with the installation of central heating has a significant impact on energy consumption.
- 2) The roof and the new slab over the basement enabled to install an important insulation.
- 3) The new windows, although they represent only 20% of the façade, have a significant effect because they combine the improvement of thermal insulation (division by 3) and the reduction of air infiltration through the better sealing.
- 4) The effect of the insulation stucco, even if it is very thin, is serious because of the large surface of the walls. In addition it allows an improvement of internal surface temperatures and thus reduces the risk of condensation.
- 5) The double-flow ventilation with heat recovery provides another 10% savings (often problematic in mid-season and summer).
- 6) With 25% savings on domestic hot water solar collectors are below their potential (30 to 40%)

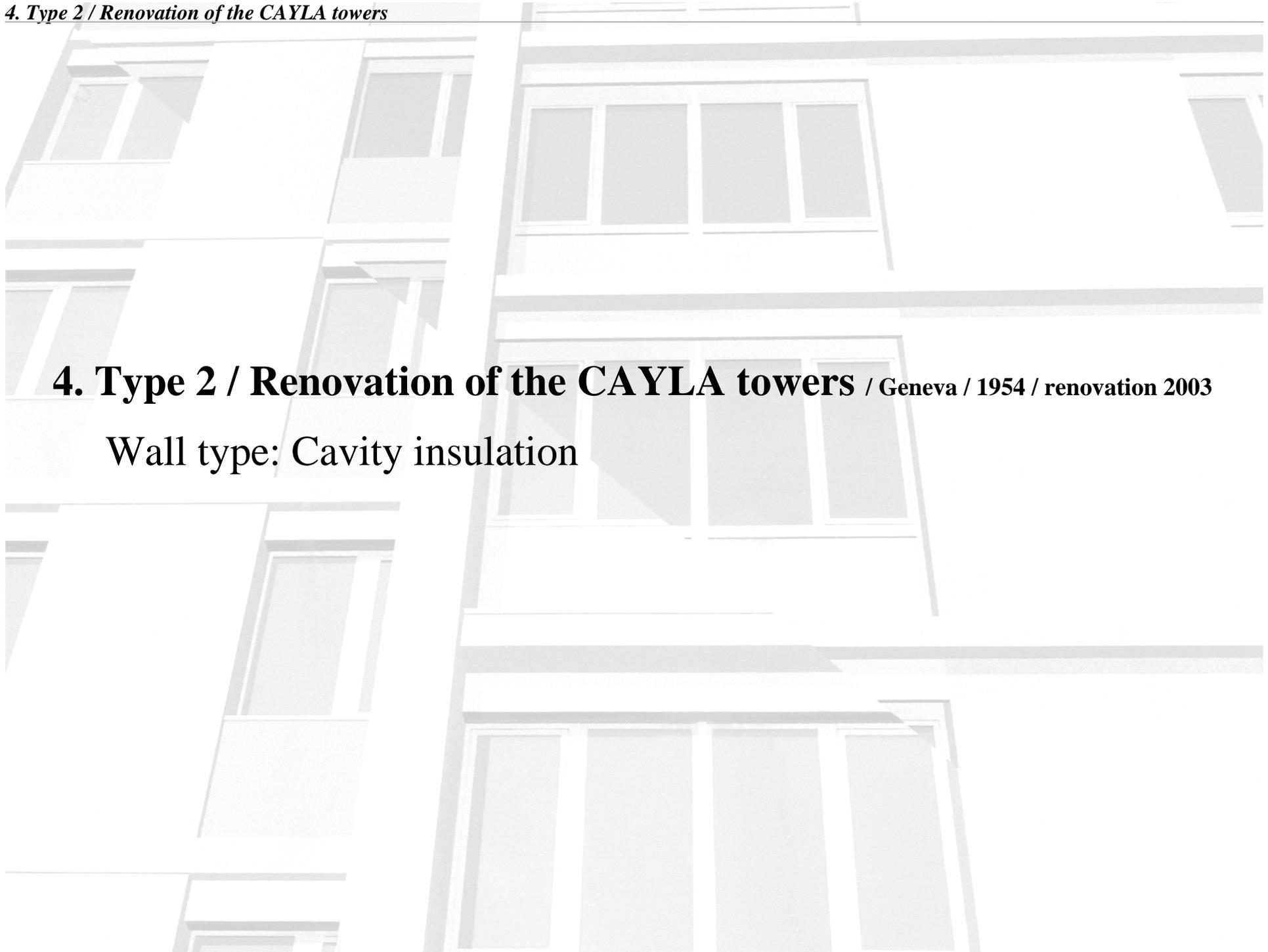
CONCLUSION

For buildings of the nineteenth century, made of stone walls, cement and lime, this renovation shows that, by simply applying a set of effective solutions, it is possible to reduce the energy consumption by more than 40%. Despite this good result, energy consumption should be reduced by half to achieve the requirements of Minergie or of the 2000 W Society that the city and townships of Geneva are aiming at. After renovation, the walls, with 53% of the heat losses, are still the weakest point. The limiting factors are:

- the embrasures of windows that limit the thickness of wall insulating rendering and cause thermal bridges,
- the risk of moisture of the head of the wooden beams.

4. Type 2 / Renovation of the CAYLA towers / Geneva / 1954 / renovation 2003

Wall type: Cavity insulation



4. Type 2 / Renovation of the CAYLA towers

SUMMARY AND PRESENTATION

The three Cayla apartment towers have been built in 1954 and renovated at the beginning of the 21st century. These modern apartment buildings have a quite particular typology (4 blocks of flats separated each by a ¼ floor level step), and are part of the Geneva inventory of protected buildings with historical value.

In bad condition, these buildings needed an important renovation that included, of course, the improvement of the whole thermal envelope. Insulation is easy to achieve for additional roof and basement and replacement of windows. But the thermal improvement of the exterior walls runs the risk of changing the image and the integrity of this 1950 modern architecture.

Finally, two of the Cayla towers were renovated with external wall insulation. Only the third tower was executed with an internal wall insulation in order to respect the decision of the CMNS (Commission des Monuments, de la Nature et des Sites) to protect the historical value of this modern architecture of the 50's.

Owner	Private
Architects	G. Addor and W. Lups
Construction	1954
Renovation	2003
Heated floor area	1928 m ²
Energy index	
• before renovation	227 kWh/m ² year
• after renovation (internal insulation)	117 kWh/m ² year
• after renovation (external insulation)	102 kWh/m ² year

Description

Insulation over basement and roof. External (two towers) and internal (one tower) insulation of the walls. New windows. Central heating with gas.

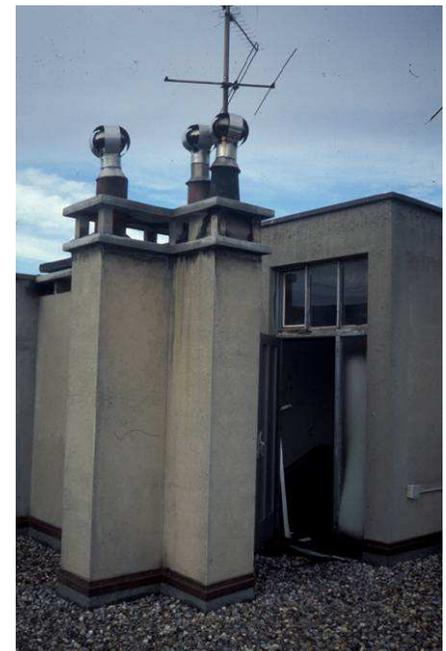
Information sources:

J. Cacheiro, architect in charge of the renovation
Architectural guide of Geneva



4. Type 2 / Renovation of the CAYLA towers

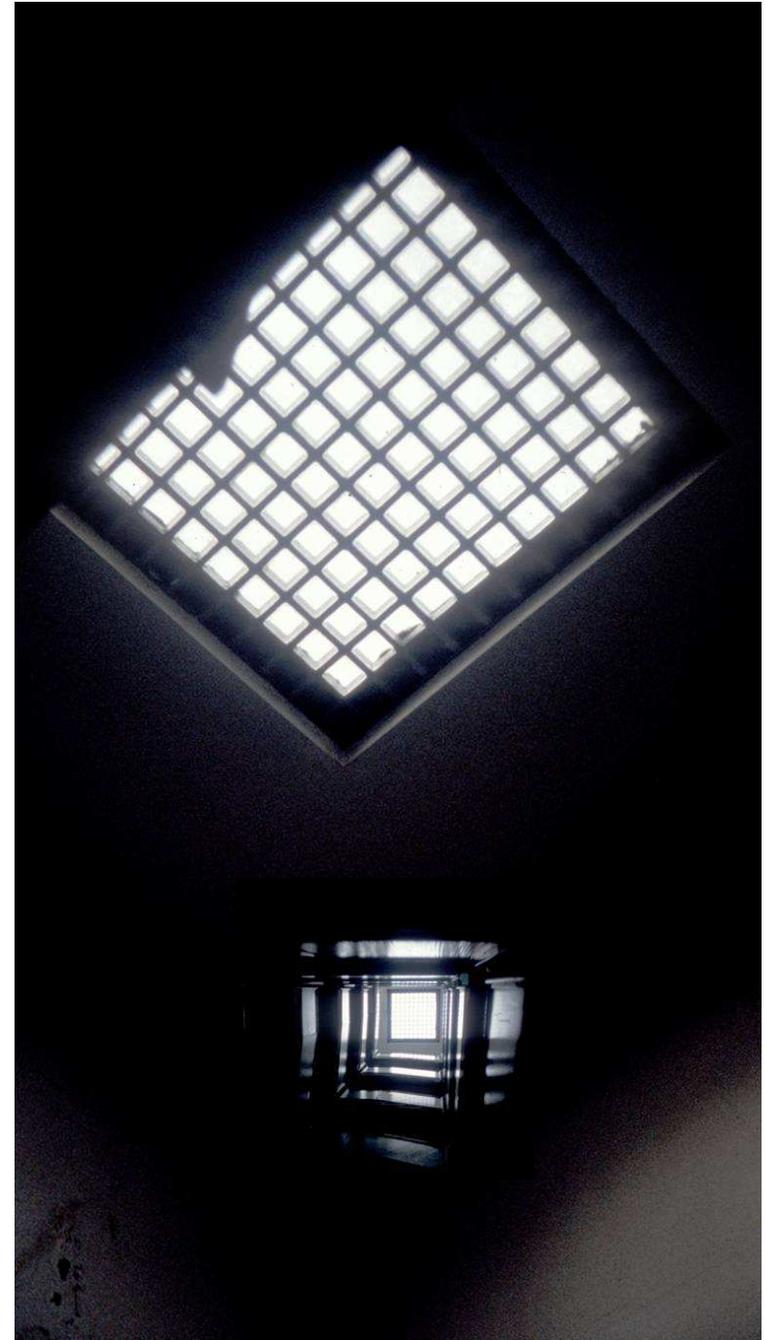
Type 2 / THE CAYLA TOWERS / Bad condition of the buildings in 2000



4. Type 2 / Renovation of the CAYLA towers



Staircase of the buildings with zenithal natural light



4. Type 2 / Renovation of the CAYLA towers

Bad condition of the buildings in 2000

Thermal bridges / All concrete walls and slabs are directly in contact with outside air (no thermal insulation).

Important heat flow through the non-insulated external walls, the roof, the basement slab and the single glazed windows.

The temperatures of the inner surfaces of the walls are cold and give moisture due to condensation (occurring typically in corner connections, window installations, etc.)



4. Type 2 / Renovation of the CAYLA towers

SIMULATIONS

Existing state (1954)

Heating / Individual oil-stove in each apartment

Hot Water / Individual electric boiler in each apartment

Roof / Concrete slab 20 cm with external thermal insulation 4 cm

Walls / Concrete 20 cm with airspace 2 cm and interior brick dubbing 4 cm (no thermal insulation)

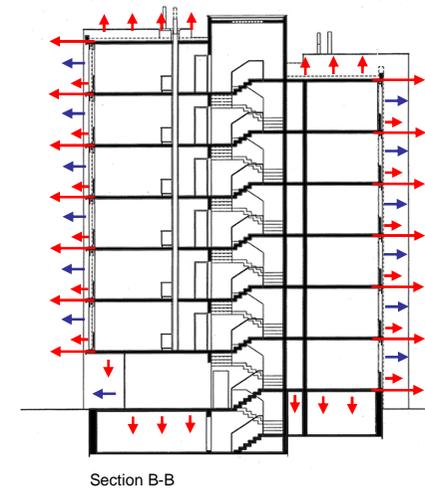
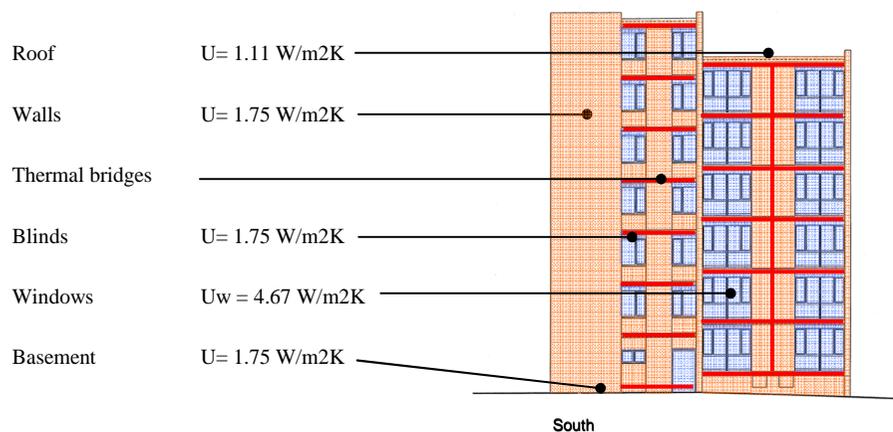
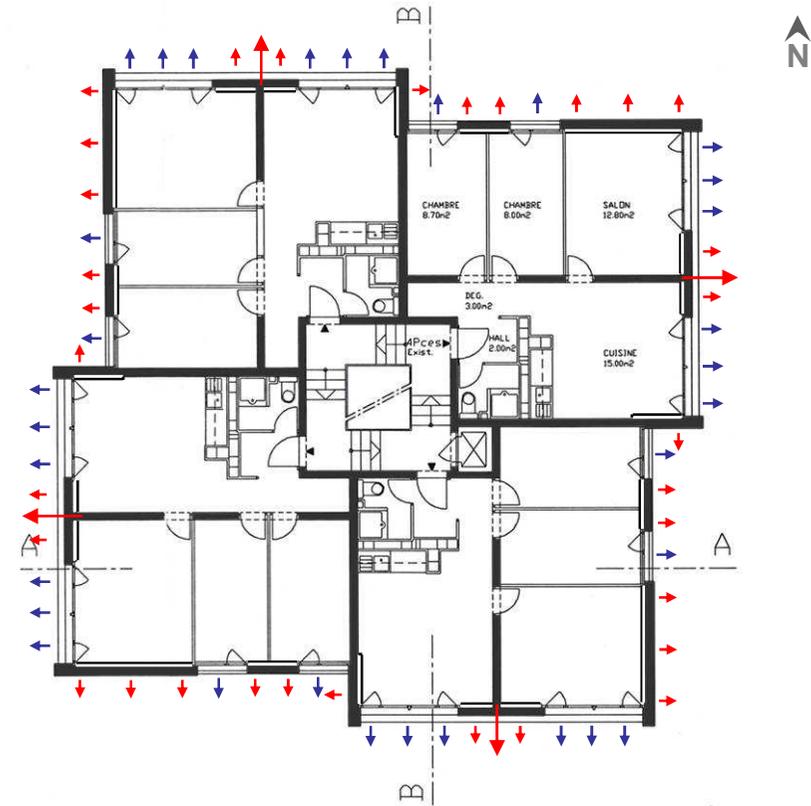
Windows / Metal frame with single glazing

Blinds / Outside slat blinds (no thermal insulation)

Basement / Concrete slab 20 cm with internal wooden floor (no thermal insulation)

Thermal bridges / All concrete walls and slabs « touch » directly the outside **ambiance** (no thermal insulation).

Important heat flow through the non insulated external walls, the roof, the basement slab and the single glazed windows.



4. Type 2 / Renovation of the CAYLA towers



VAR 01

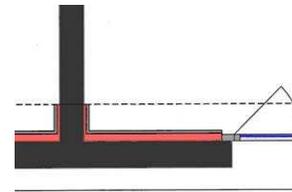
Heat production:	New central heating gas-fired boiler for heating and hot water	
Heat distribution:	New radiators in each room	
Roof:	Additional thermal insulation 20 cm over the roof slab	U= 0.20 W/m2K
Basement:	Additional thermal insulation 10 cm under the ground floor slab	U= 0.40 W/m2K

VAR 02

Heat production:	New central heating gas-fired boiler for heating and hot water	
Heat distribution:	New radiators in each room	
Roof:	Additional thermal insulation 20 cm over the roof slab	U= 0.20 W/m2K
Basement:	Additional thermal insulation 10 cm under the ground floor slab	U= 0.40 W/m2K
Windows:	New thermal-break metal frame with double-glazing	U= 1.60 W/m2K
Blinds:	New blinds with sandwich panel including thermal insulation	U= 0.60 W/m2K

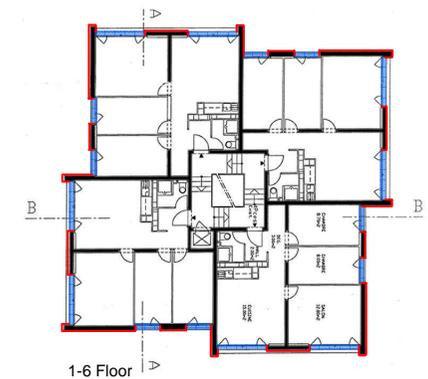
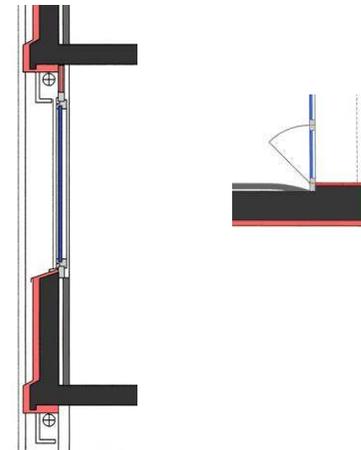
VAR 03 / Internal wall insulation / Realized on building « 7, rue du Contrat-Social »

Heat production:	New central heating gas-fired boiler for heating and hot water	
Heat distribution:	New radiators in each room	
Roof:	Additional thermal insulation 20 cm over the roof slab	U= 0.20 W/m2K
Basement:	Additional thermal insulation 10 cm under the ground floor slab	U= 0.40 W/m2K
Windows:	New thermal-break metal frame with double-glazing	U= 1.60 W/m2K
Blinds:	New blinds with sandwich panel including thermal insulation	U= 0.60 W/m2K
Walls:	Replacement of the existing interior dubbing by a layer of thermal insulation 6 cm and plasterboards 2.6 cm	U= 0.65 W/m2K



VAR 04 / External wall insulation / Realized on building « 5, chemin William-Lescage »

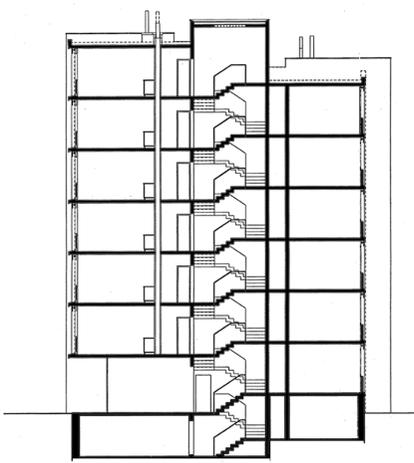
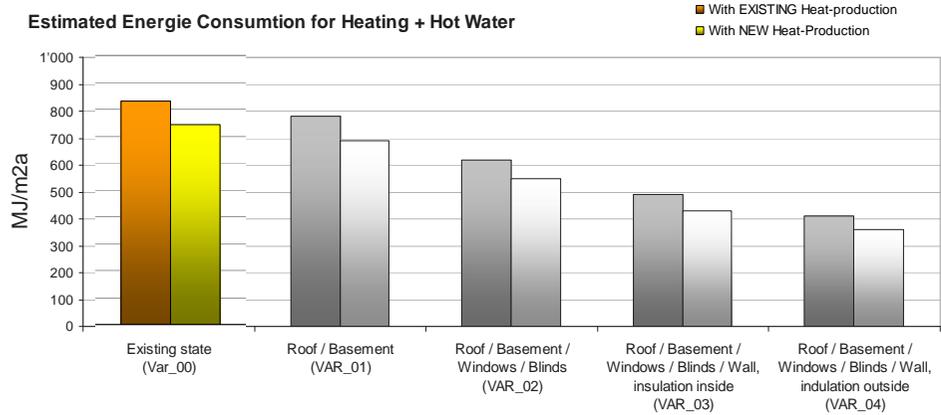
Heat production:	New central Heating gas-fired boiler for heating and hot water	
Heat distribution:	New radiators in each room	
Roof:	Additional thermal insulation 20 cm over the roof slab	U= 0.20 W/m2K
Basement:	Additional thermal insulation 10 cm under the ground floor slab	U= 0.40 W/m2K
Windows:	New thermal-break metal frame with double-glazing	U= 1.60 W/m2K
Blinds:	New blinds with sandwich panel including thermal insulation	U= 0.60 W/m2K
Walls:	External thermal insulation 4-8cm with exterior coating	U= 0.63 W/m2K
Thermal bridges:	Elimination of all thermal bridges	



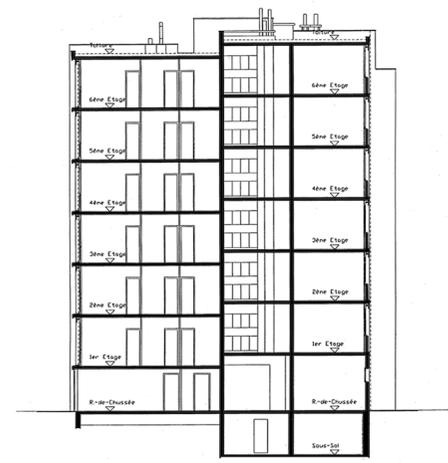
SIMULATION / VAR_00 / ORIGINAL STATE (1954)



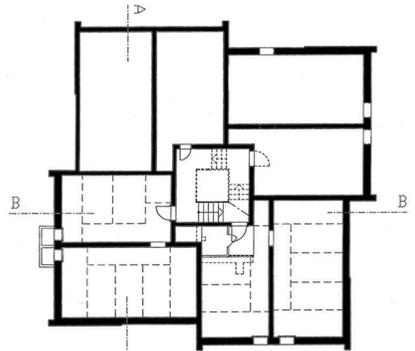
Estimated Energy Consumption for Heating + Hot Water



Section B-B



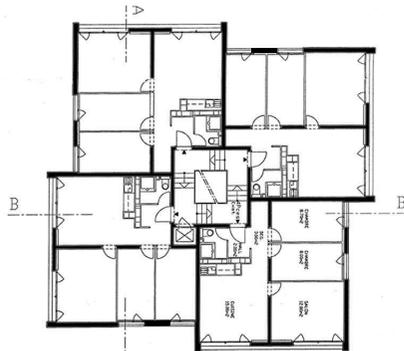
Section A-A



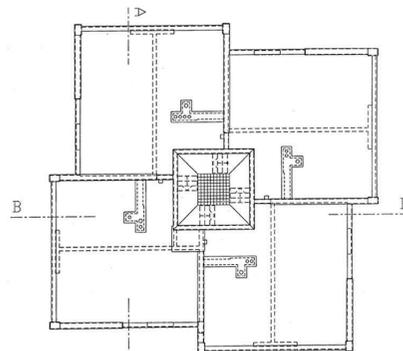
Basement



Ground



1-6 Floor



Roof



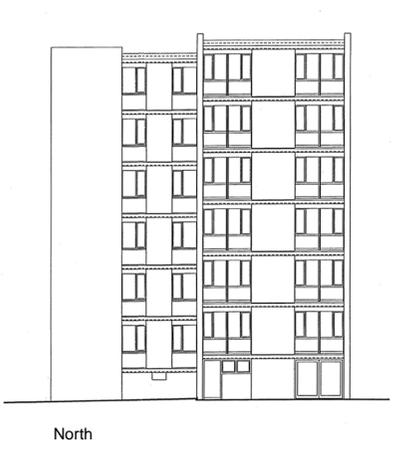
West



South



East

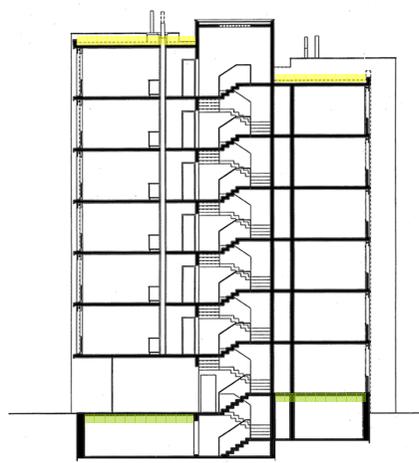
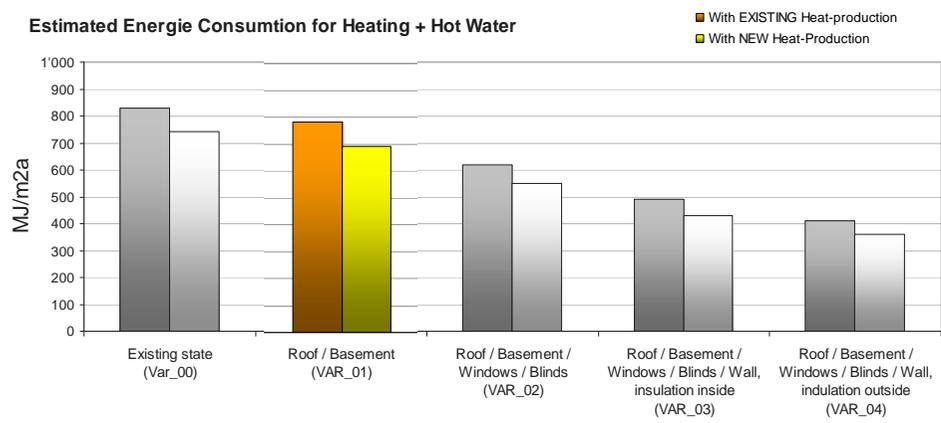


North

SIMULATION / VAR_01 / RENOVATION (2003) / roof-insulation / basement-insulation



Estimated Energy Consumption for Heating + Hot Water



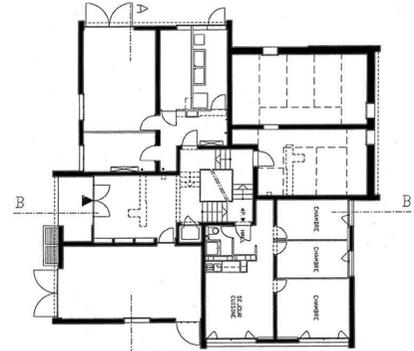
Section B-B



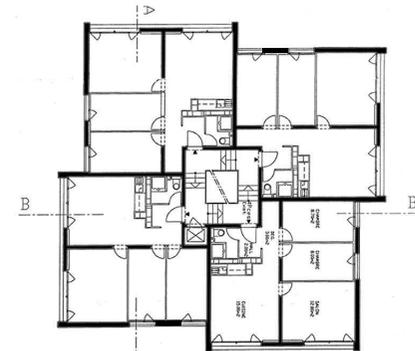
Section A-A



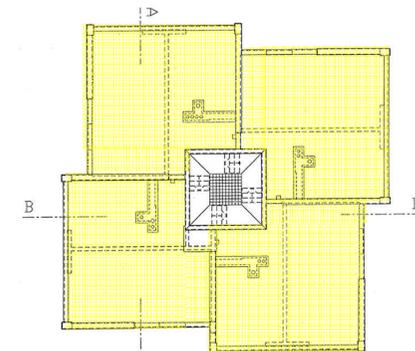
Basement



Ground



1-6 Floor



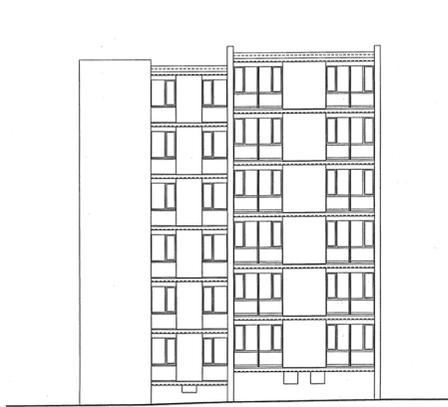
Roof



West



South



East

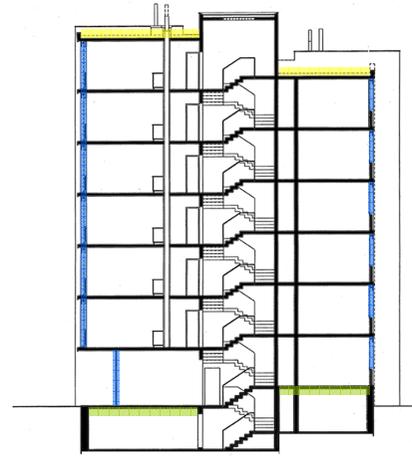
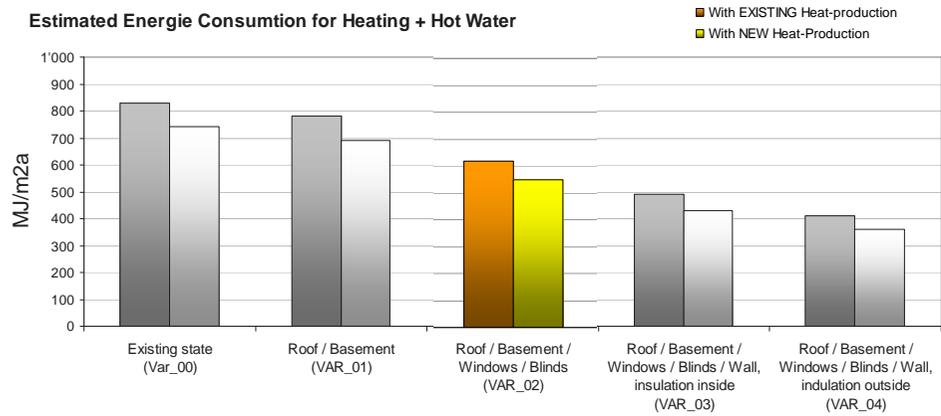


North

SIMULATION / VAR_02 / RENOVATION (2003) / roof-insulation / basement-insulation / windows / blinds



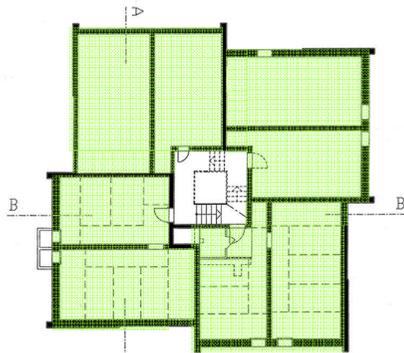
Estimated Energy Consumption for Heating + Hot Water



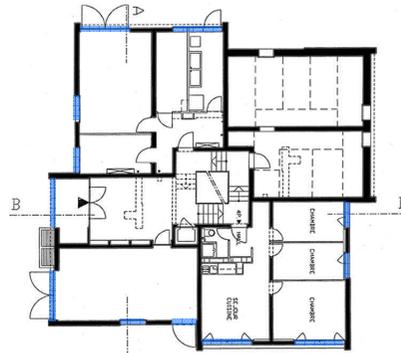
Section B-B



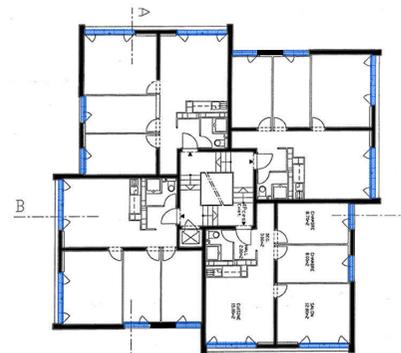
Section A-A



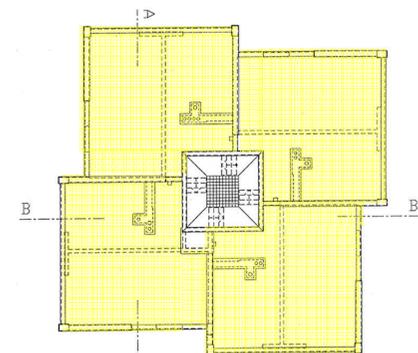
Basement



Ground



1-6 Floor



Roof



West



South



East

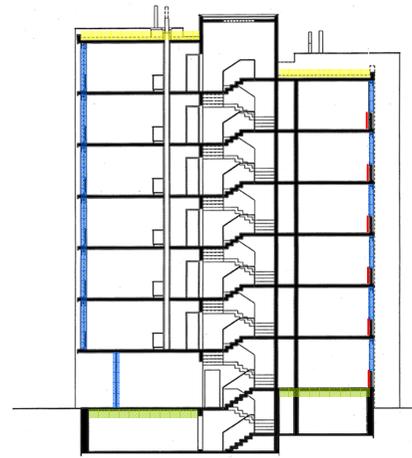
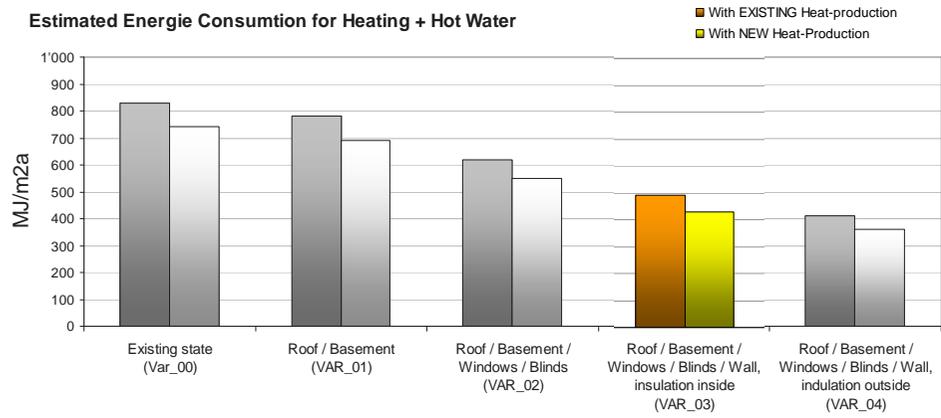


North

SIMULATION / VAR_03 / RENOVATION (2003) / roof-insulation / basement-insulation / windows / blinds / internal wall insulation



Estimated Energy Consumption for Heating + Hot Water



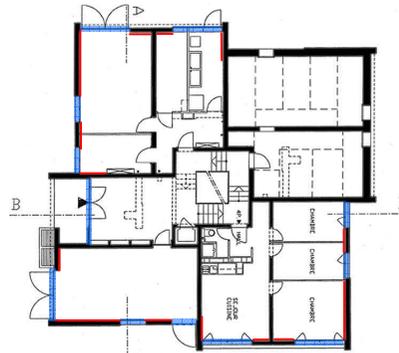
Section B-B



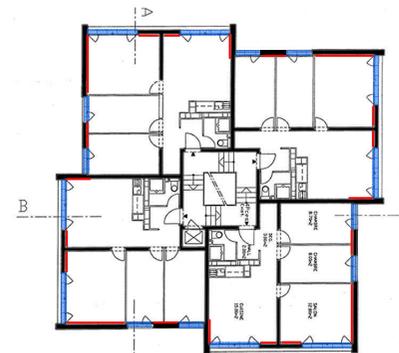
Section A-A



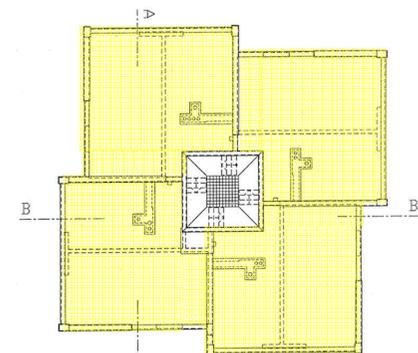
Basement



Ground



1-6 Floor



Roof



West



South



East

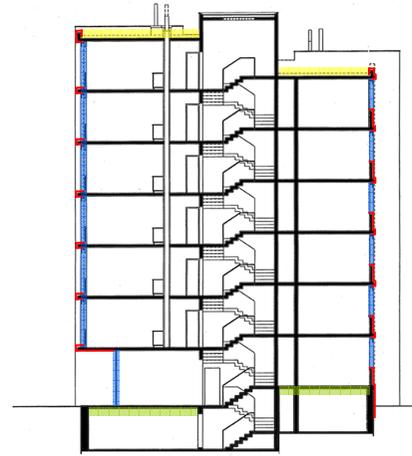
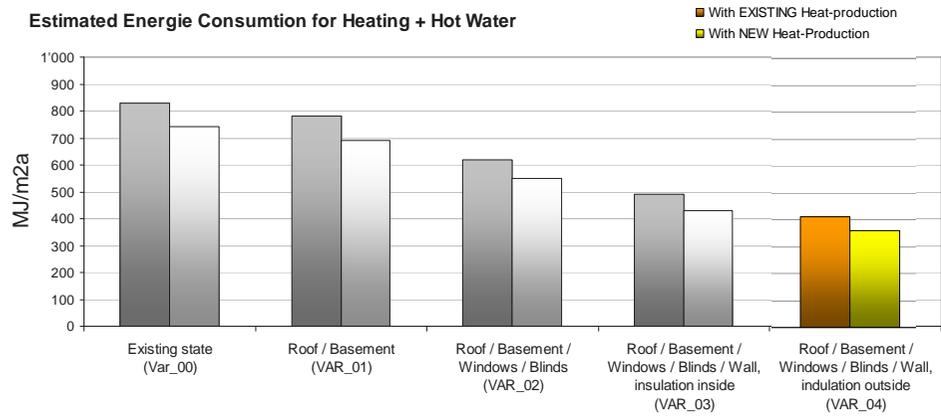


North

SIMULATION / VAR_04 / RENOVATION (2003) / roof-insulation / basement-insulation / windows / blinds / external wall insulation



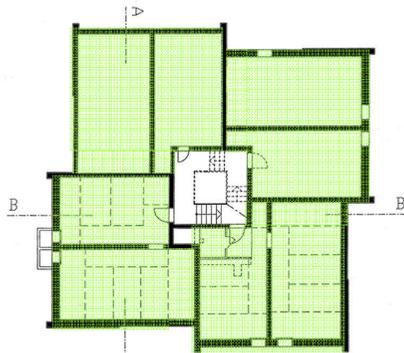
Estimated Energy Consumption for Heating + Hot Water



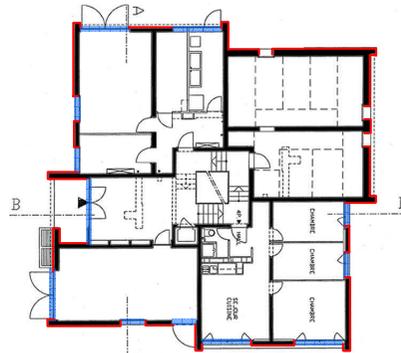
Section B-B



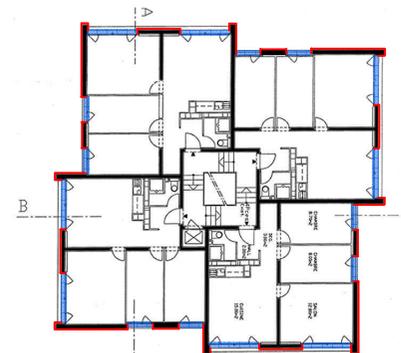
Section A-A



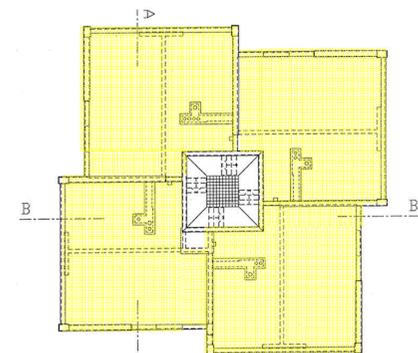
Basement



Ground



1-6 Floor



Roof



West



South

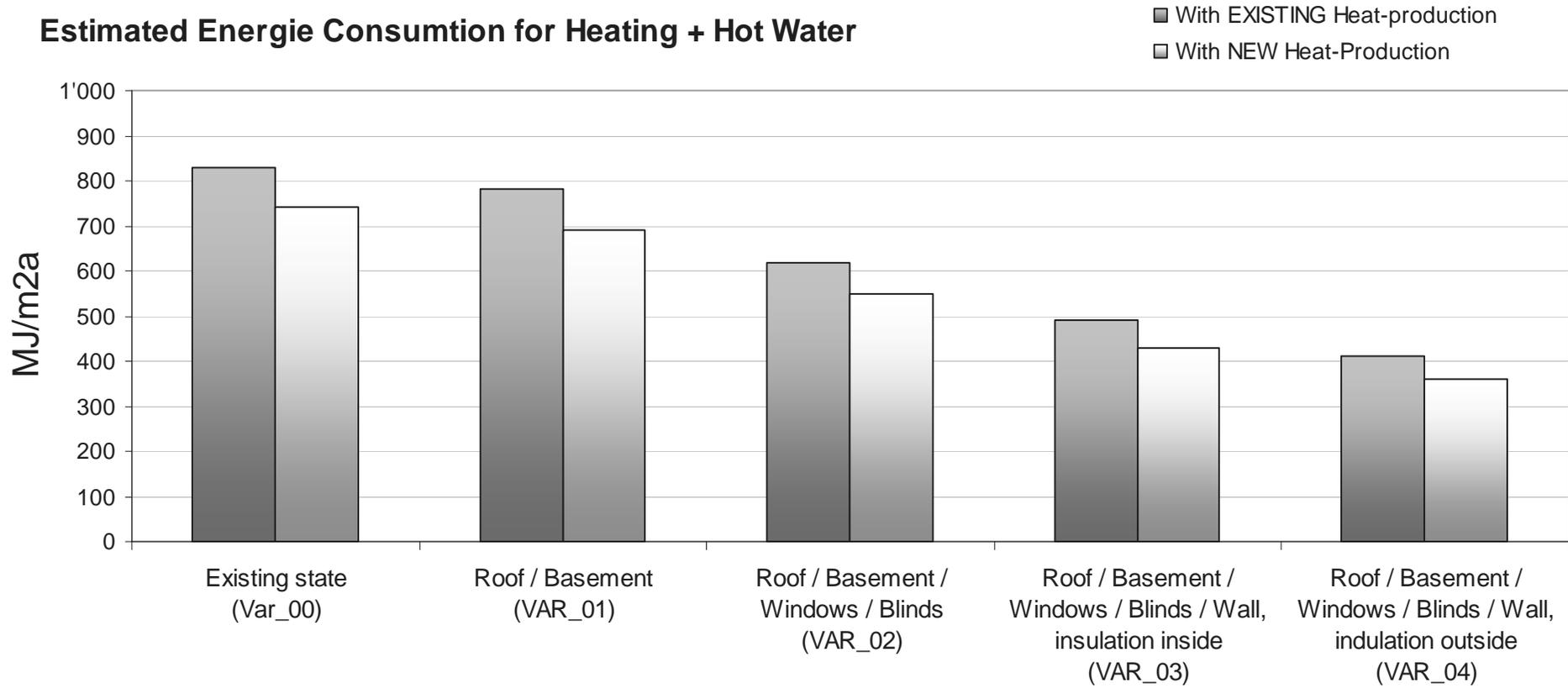


East



North

Estimated Energie Consumption for Heating + Hot Water



PROJECT 2001



Existing state (before renovation)



Drawing with external insulation

4. Type 2 / Renovation of the CAYLA towers

PROTOTYPE OF EXTERNAL INSULATION OF THE FAÇADE (2003)



4. Type 2 / Renovation of the CAYLA towers

APPEARANCE OF THE BUILDINGS AFTER RENOVATION (2003)



Realisation with **EXTERNAL** wall insulation



Realisation with **INTERNAL** wall insulation

THE CAYLA TOWERS / Experience about the influence of external and internal insulation in the appearance of buildings

CONCLUSION

The Cayla towers' renovation presents thus an experience of the influence of external and internal insulation in the appearance of protected buildings with historical value.

With only 4 to 8 cm external insulation, the result is surprising: no major image difference between the inside and outside insulated walls. Of course, the « historical value imperatives » limits the thickness of the external thermal wall insulation. This dimensioning of the thickness of the thermal insulation just covered with coating allows to maintain the proportions of the different elements constituting the architectural expression of the façade.

Some differences appear because of the necessity to protect this external insulation against rain by the addition of small aluminium elements under the windows. However, the aging of this external insulation, with a quit complex geometry, only protected by a coating can be questioned.

But the Cayla tower renovation presents an intelligent compromise between the improvement of the thermal quality of building envelopes and the protection of buildings with historical value.

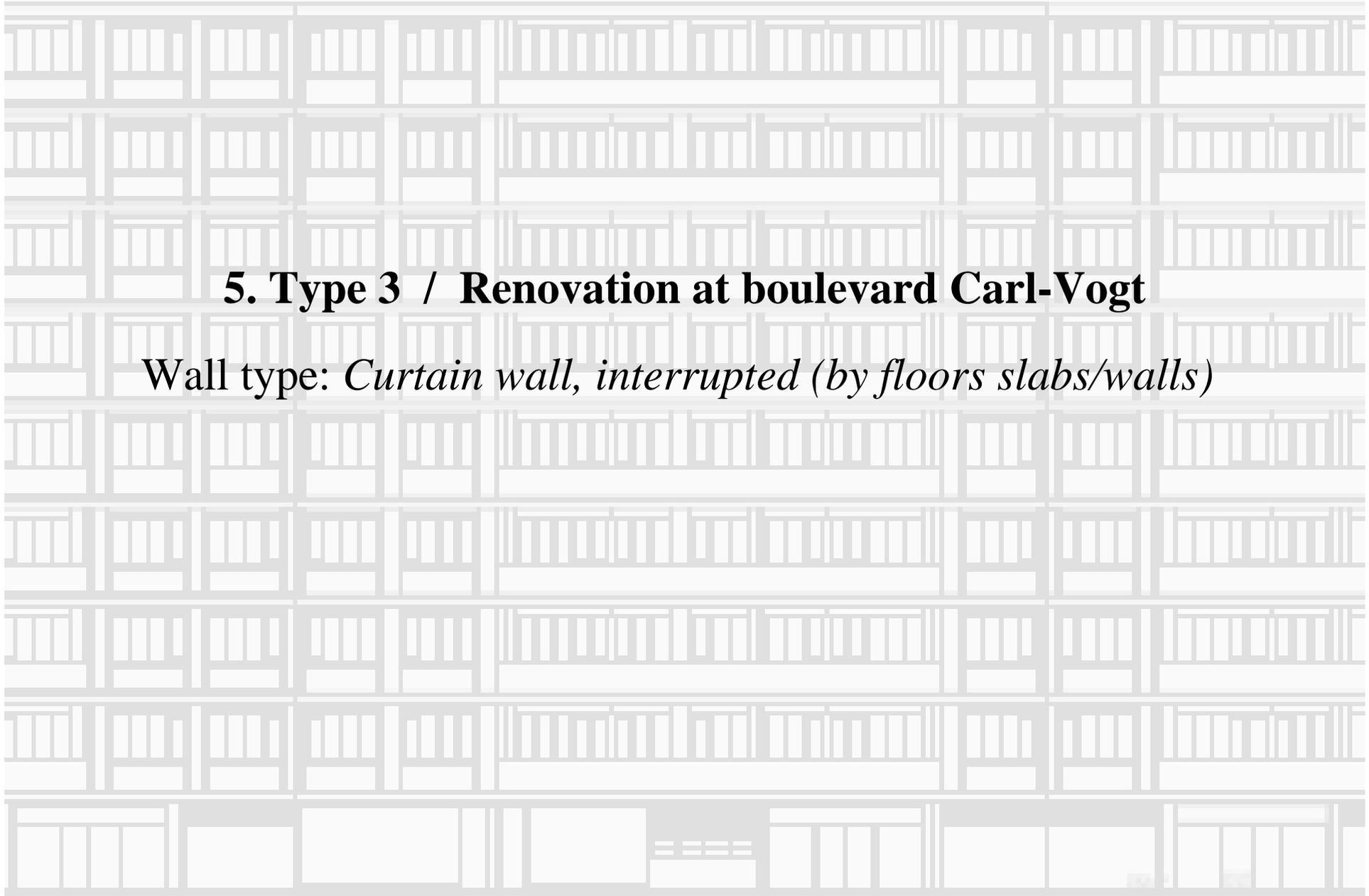
With external insulation, energy consumption is around 15 kWh/m²year lower than with internal insulation. The difference is mainly due to thermal bridges.

Nevertheless, energy consumption after renovation for heating and hot water is more than two times lower than before the renovation (228 kWh/m²year to less than 110 kWh/m²year) confirmed with simulations.

With external insulation, energy consumption is around 15 kWh/m²year lower than with internal insulation. Difference is mainly due to thermal bridges.

5. Type 3 / Renovation at boulevard Carl-Vogt

Wall type: *Curtain wall, interrupted (by floors slabs/walls)*



5. Type 3 / Renovation at boulevard Carl-Vogt

SUMMARY

Honegger Brothers, with their prefabrication system developed in Morocco (Morocco Standard), have built many apartment buildings (4170 apartments) in Geneva between 1954 and 1965. Despite their remarkable durability, these buildings now require renovations and transformations that include adaptation to new standards and urban transformations. The high quality of these buildings is protected by the Office of Monuments and Sites. This analyse of the building N° 2 of the City of Carl-Vogt is based on the work of Ana Baechler, made for her DEA at the Institute of Architecture in Geneva.

Owner	Caisses de pension
Architects	Honegger Brothers
Construction	1962
Renovation	Planned 2011 ?
Heated surface	8498 m ²

Energy demand for heating

• before renovation	160 kWh/m ² an
• after renovation (“Rehabilitation A”)	74 kWh/m ² an
• after renovation (“Transformation”)	43 kWh/m ² an

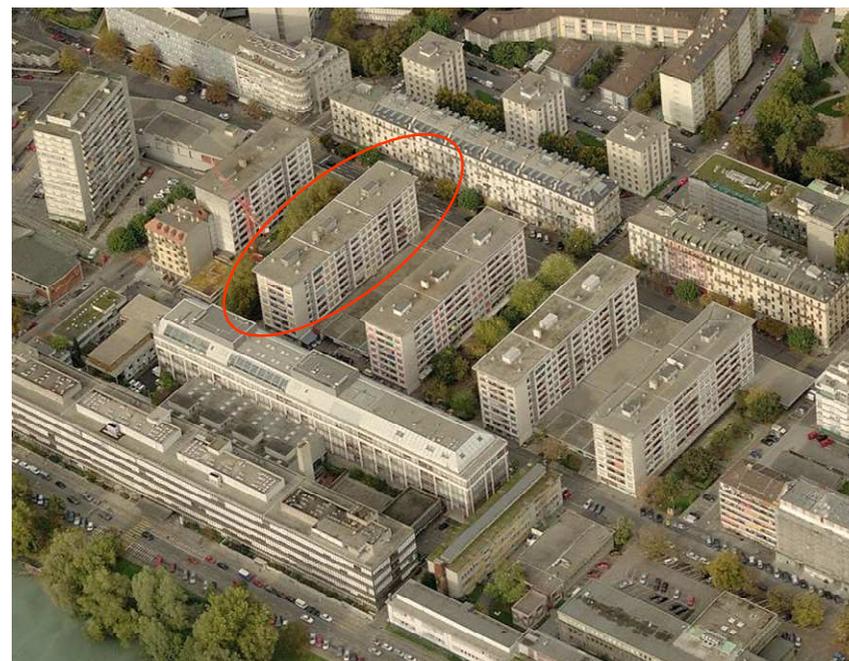
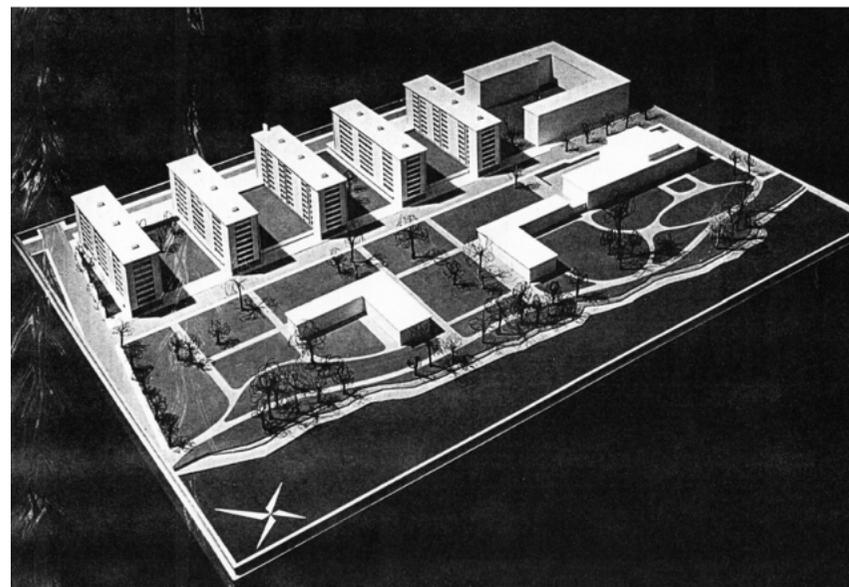
Description

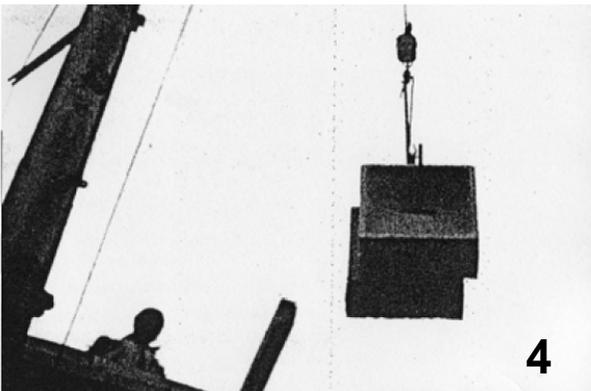
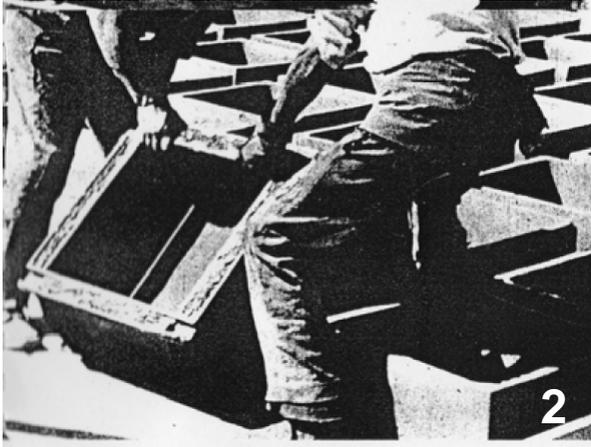
Insulation over basement and roof. External insulation of the walls (insulating rendering 4-6 cm). New windows (glass U 1.1 W/m²K).

Information sources:

Ana Beachler “Les frères Honegger, Cité Carl-Vogt, projet d’amélioration thermique”, 2007.

J.-J. Honegger “raconte Honegger Frères”, 1982, Genève.

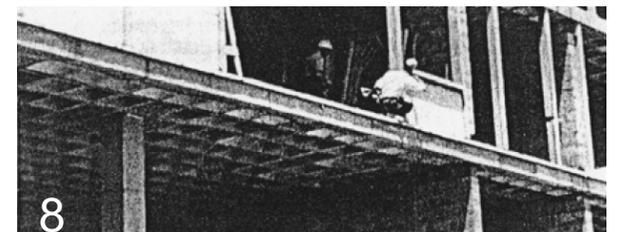
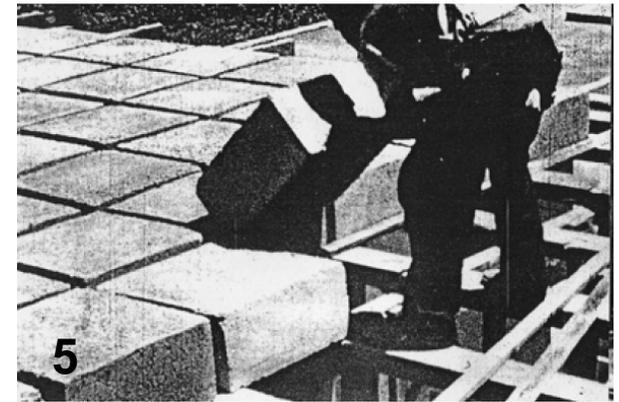




HONEGGER SYSTEM

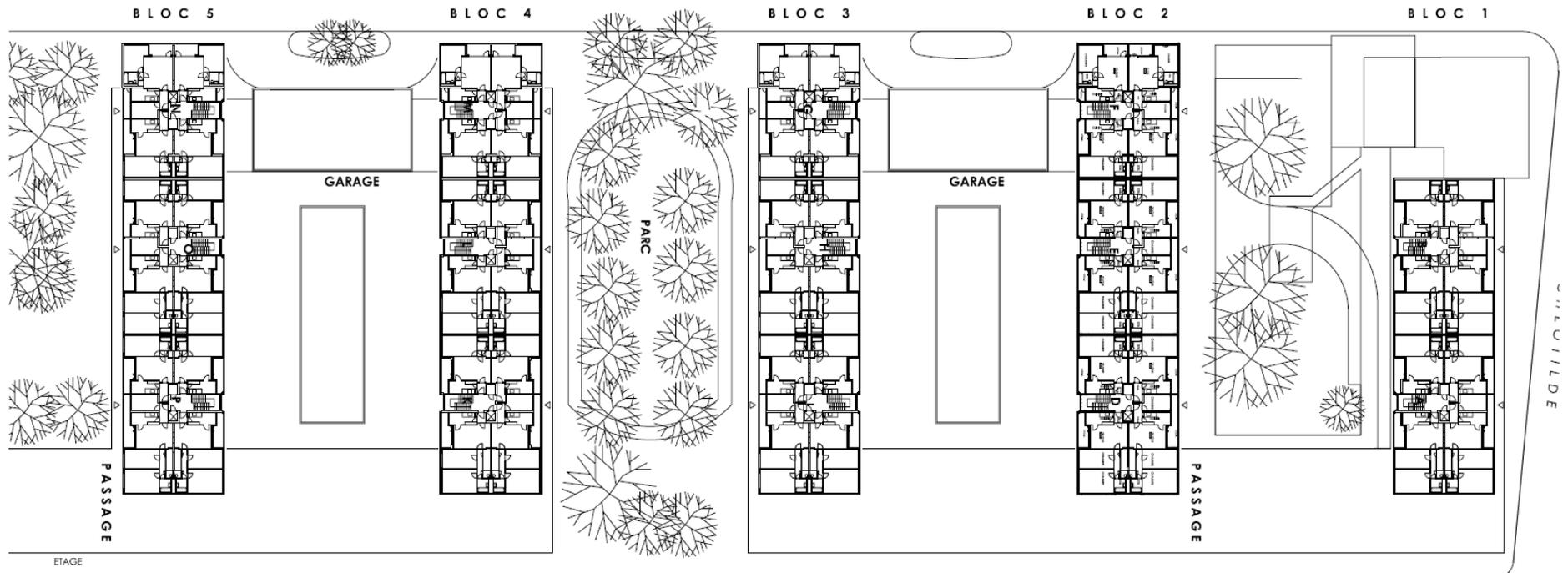
The Honegger constructions are based on a system of reinforced caisson for the buildings' slabs. These caissons are assembled leaving in between a space of 6 cm. These spaces will shape the concrete structure of the floor slabs.

- 1 Concrete is poured in the formwork
- 2 Unmolding of the caisson
- 3 Shuttering of the floor slab
- 4 Lifting of two caisson
- 5 Laying down a caisson
- 6 Concrete is poured in the rib of the slab
- 7 and 8 Caissons in unmolded floor slab

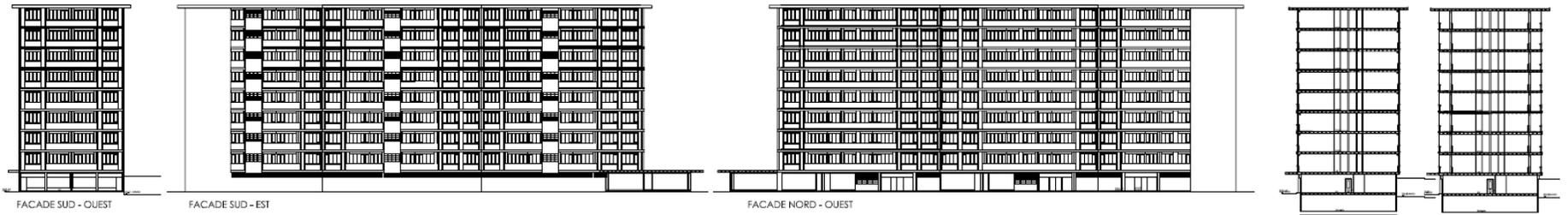


5. Type 3 / Renovation at boulevard Carl-Vogt

PLANS, FACADES AND SECTIONS



ETAGE



FACADE SUD - OUEST

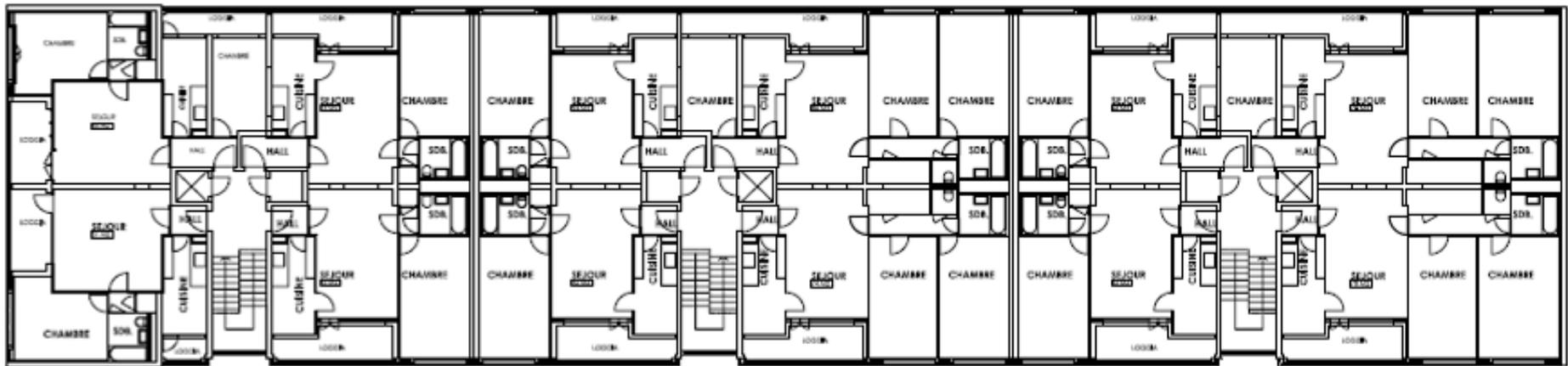
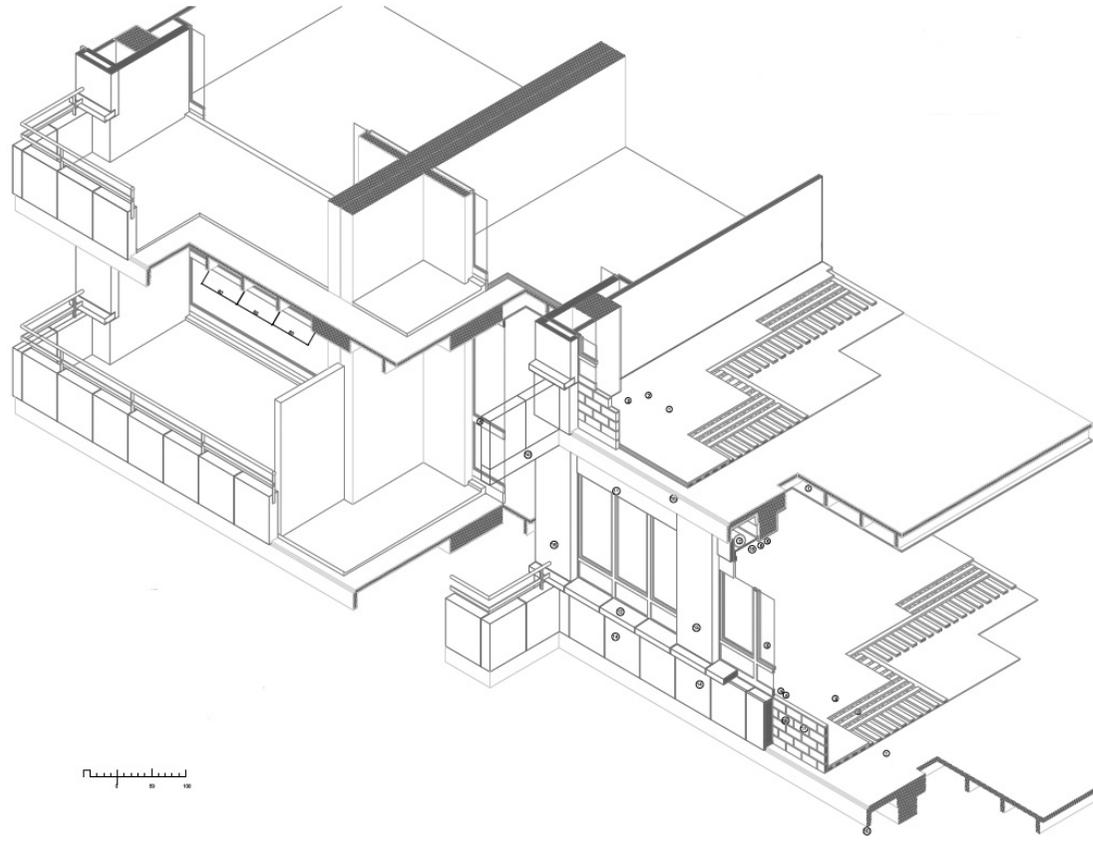
FACADE SUD - EST

FACADE NORD - OUEST

FACADE NORD-EST

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5. Type 3 / Renovation at boulevard Carl-Vogt



Floor plan 2-9

SIMULATION

In order to identify opportunities for improvements, while maintaining its architectural qualities, energy savings are analysed at different steps of renovation. Based on the detailed study of the existing building and technical possibilities for thermal improvements, various hypotheses of interventions have been simulated, from simple to heavy renovations. We are presenting the tree main steps of the improvement of the envelop:

- In the solution called “rehabilitation”, interventions are: strengthening of existing insulation, punctual insulation of ground floor when needed and improvement of glazing as required by the law.
- In the eventuality of a "renovation", in addition to what was done in “rehabilitation”, we have the replacement of existing glazing by high insulating glasses, and internal insulation of the envelop. The regulation of natural ventilation remains.
- Finally, the "transformation" that includes an important external insulation, 12 cm.

5. Type 3 / Renovation at boulevard Carl-Vogt

SIMULATION / EXISTING STATE

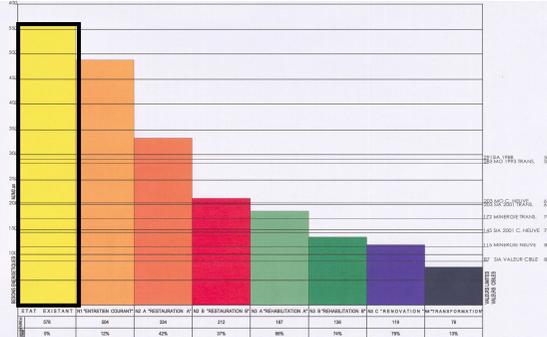
Terms of use

Internal temperature	20°C
Hot water	21 kWh/m ² an
The hourly supply air flow-rates	0.1.2. m ³ /m ²

Energy

Heating	160 kWh/m ² an
Energy index, heating + hot water	181 kWh/m ² an

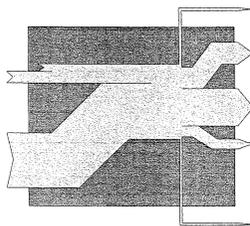
Comparison of energy consumption of existing and different types of renovations



Apports internes
10.4 %

Apports solaires
15.4 %

Besoins chauffage
74.1 %



Pertes toiture
3.9 %

Pertes murs
28.8 %

Pertes vitrages
49.5 %

Pertes ventilation
14.7 %

Pertes plancher
3.1 %

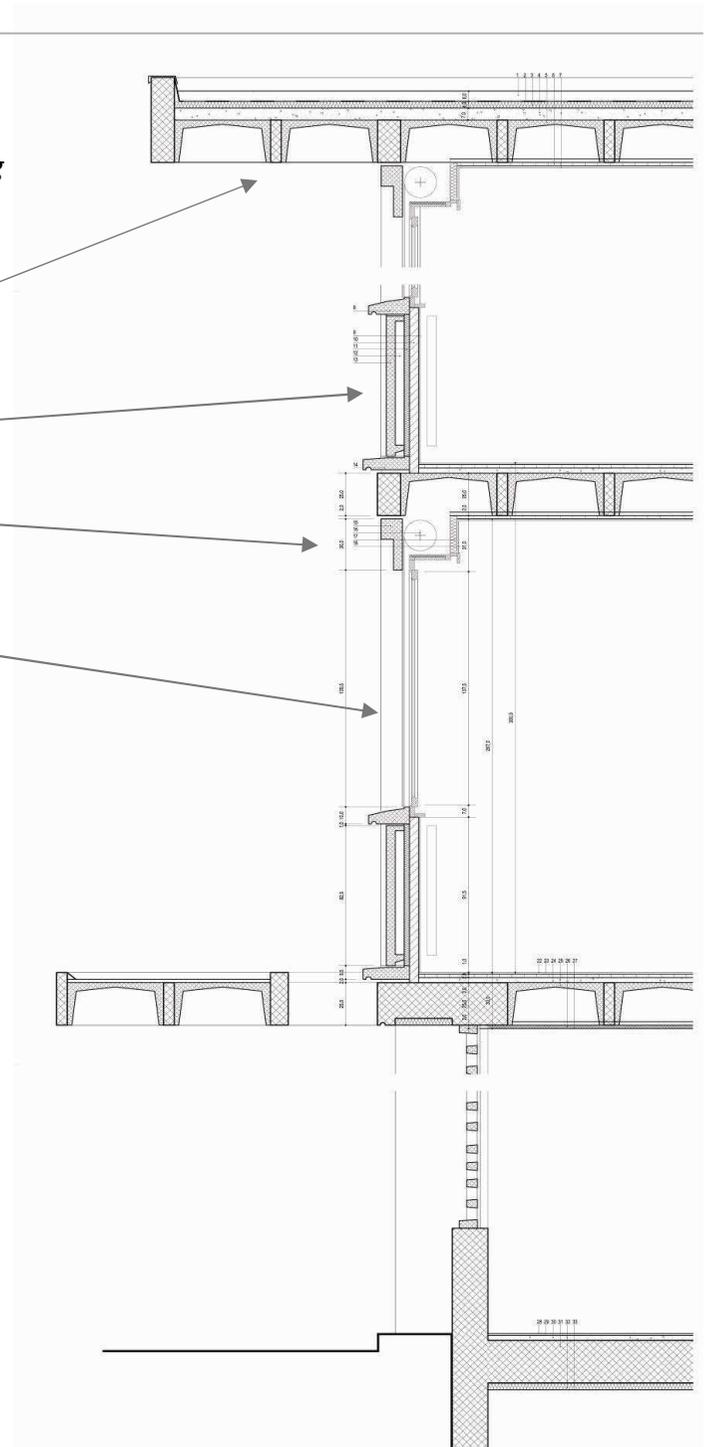
Section of existing building

Box (caisson) structure

Prefabricated element

Roller blind

Single glazed window with wooden frame



5. Type 3 / Renovation at boulevard Carl-Vogt

SIMULATION / RESTORATION

Terms of use

Internal temperature 20°C
 Hot water 21 kWh/m²an
 Hourly supply air flow-rates 0.8. m³/m²

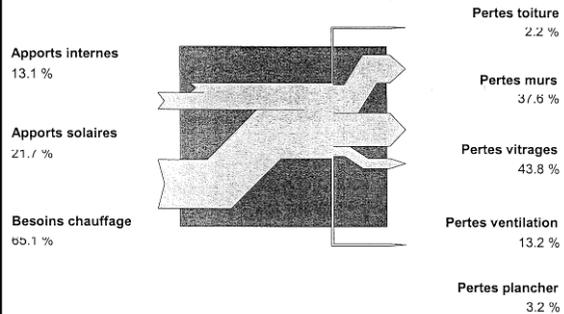
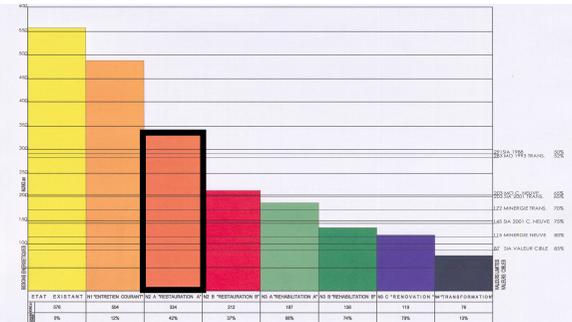
Energy

Heating 93 kWh/m²an
 Energy index, heating + hot water 114 kWh/m²an

Savings

67 kWh/m²an

Comparison of energy consumption of existing and different types of renovations



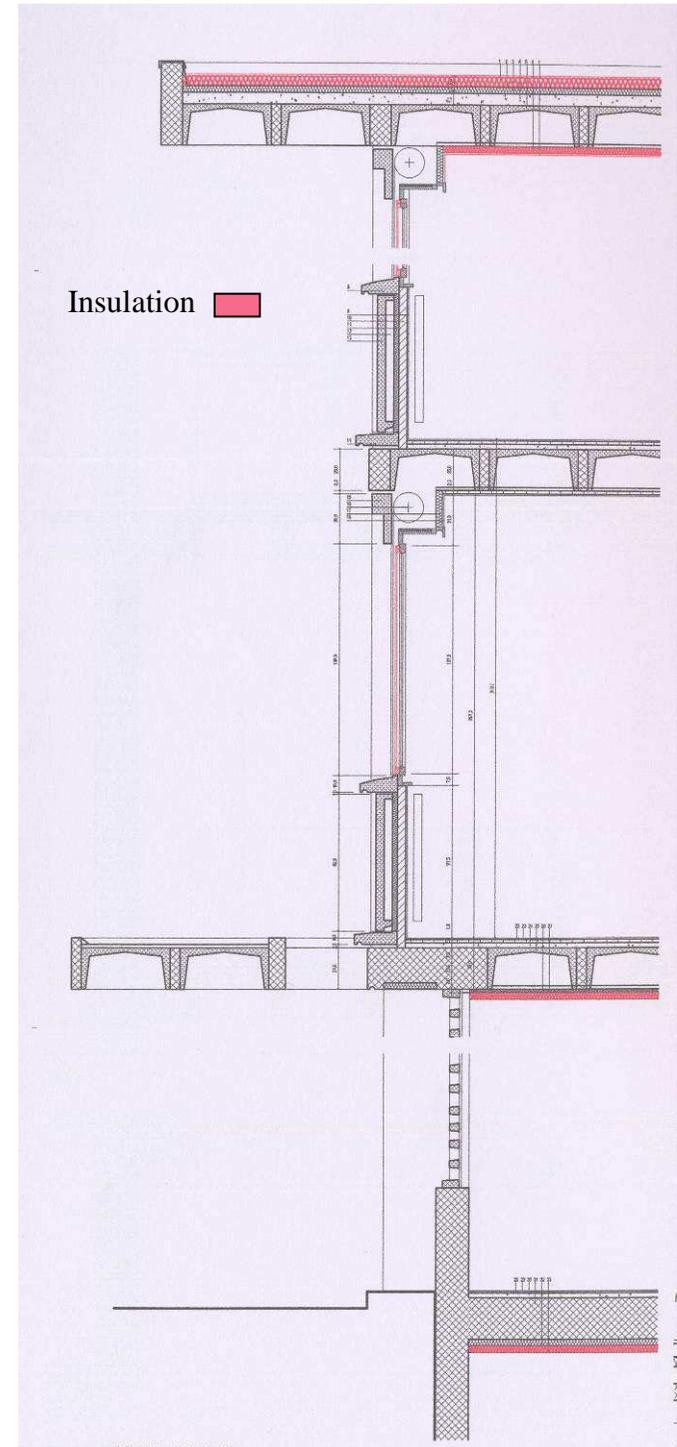
Improvements

Roof: Gravel replaced by 6 cm of Roofmate insulation

Roof: Replacement of the false ceiling with 4 cm Rockwool insulation

Windows: Additional single glazing panels are provided outside the existing window

Basement: Replacement of existing insulation over the basement



5. Type 3 / Renovation at boulevard Carl-Vogt

SIMULATION / REHABILITATION

Terms of use

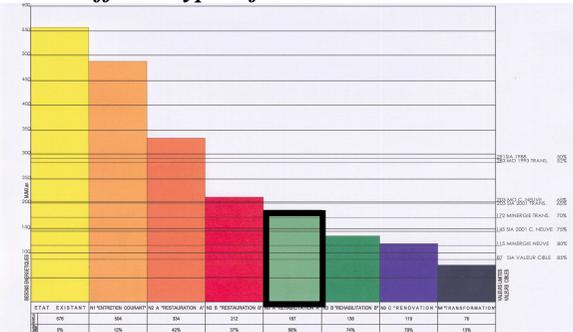
Internal temperature	20°C
Hot water	21 kWh/m ² an
Hourly supply air flow-rates	0.8 m ³ /m ²

Energy

Heating	38 kWh/m ² an
Energy index, heating + hot water	59 kWh/m ² an

Savings 122 kWh/m²an

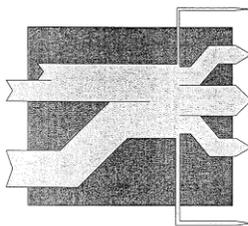
Comparison of energy consumption of existing and different types of renovations



Apports internes
22.2 %

Apports solaires
28.7 %

Besoins chauffage
49.1 %



Pertes toiture
3.5 %

Pertes murs
25.0 %

Pertes vitrages
41.1 %

Pertes ventilation
24.5 %

Pertes plancher
5.9 %

Improvements in addition of restoration

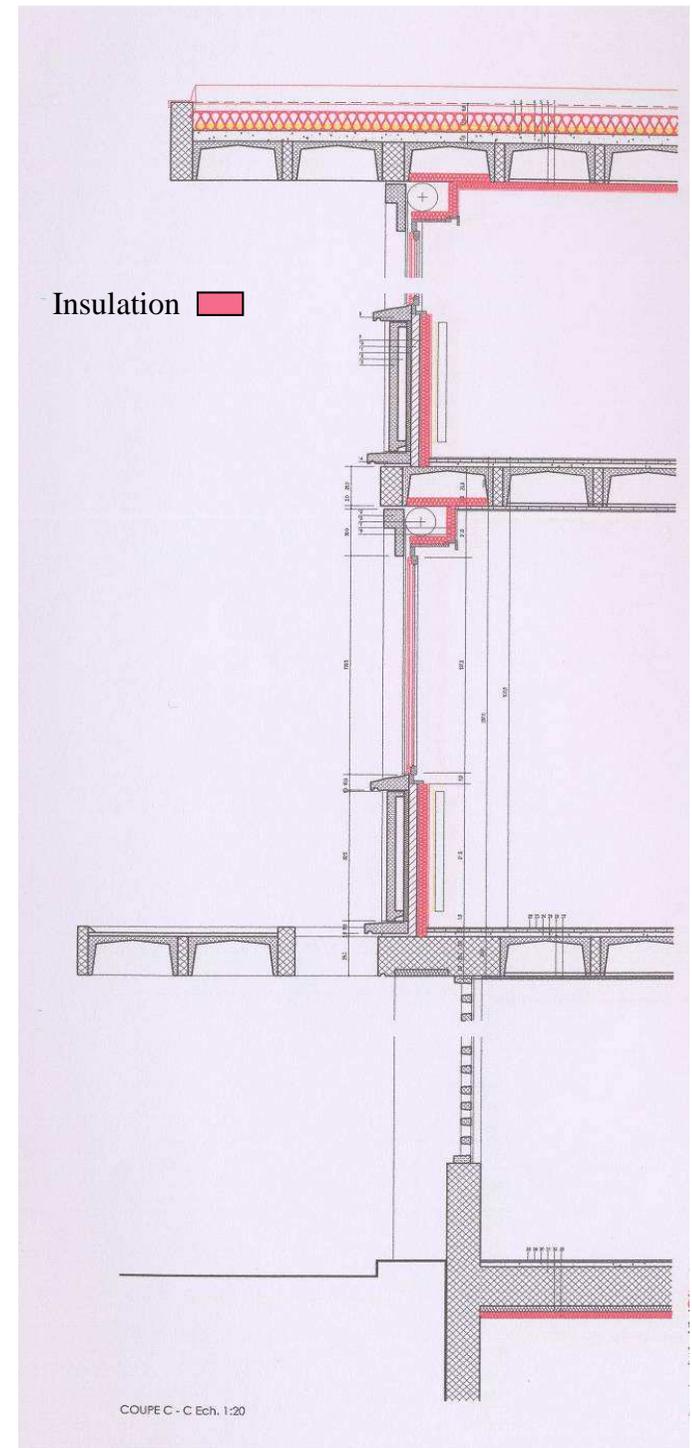
Roof: 12 cm of cellular glass insulation

Window breast: enhancement of insulation with 4 cm Rockwool

Windows: single glaze replaced by a double glaze U = 1.1 W/m²K

Roller blind: Insulation with 4 cm Rockwool

Basement: same as restoration



5. Type 3 / Renovation at boulevard Carl-Vogt

SIMULATION / TRANSFORMATION

Terms of use

Internal temperature 20°C
 Hot water 21 kWh/m²an
 The hourly supply air flow-rates 0.7 m³/m²

Energy

Heating 21 kWh/m²an
 Energy index, heating + hot water 41 kWh/m²an

Savings

139 kWh/m²an

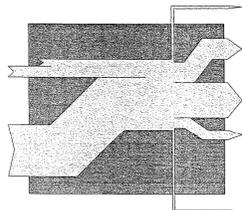
Comparison of energy consumption of existing and different types of renovations



Apports internes
10.4 %

Apports solaires
15.4 %

Besoins chauffage
74.1 %



4.1 %
Pertes toiture
3.9 %

Pertes murs
28.8 %

Pertes vitrages
49.5 %

Pertes ventilation
14.7 %

Pertes plancher
3.1 %

Improvements in addition of rehabilitation

Roof: 18 cm of cellular glass insulation

Walls: External wall insulation (12 cm Rockwool) renders and finishes.

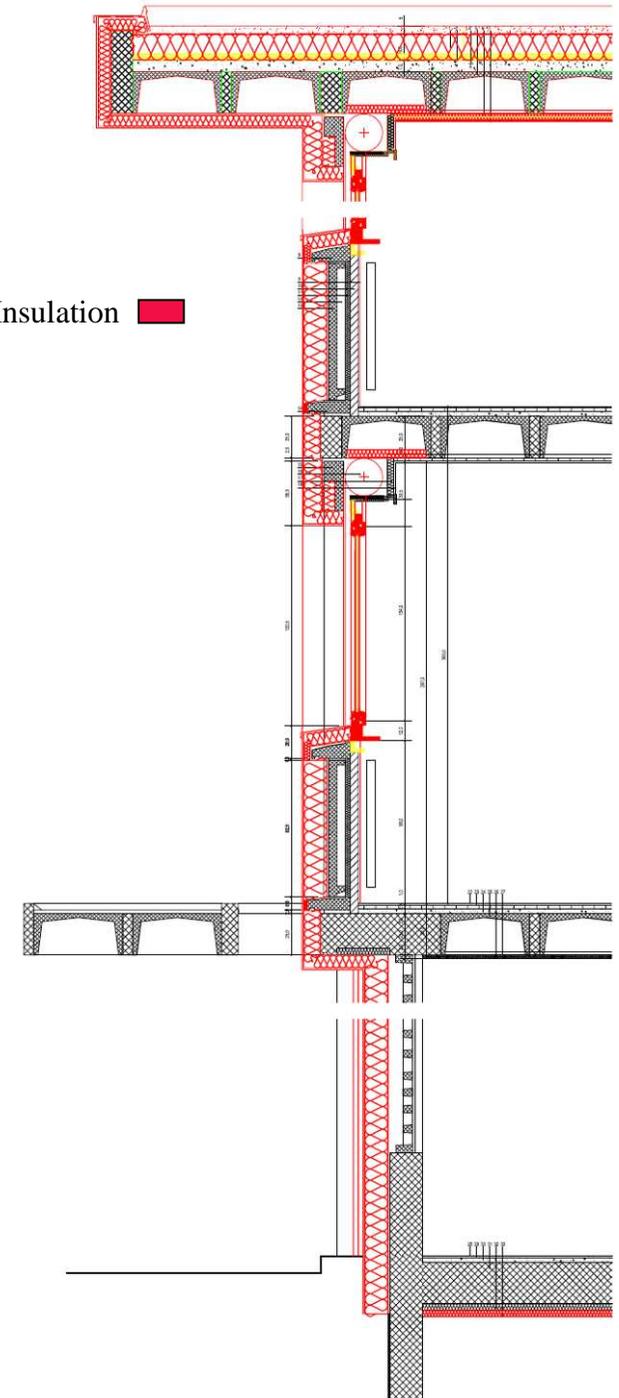
Window breast: enhancement of insulation with 4 cm Rockwool

Windows: new aluminium and wood frames with double glazing (U = 0.8 W/m²K)

Roller blind: Insulation with 4 cm Rockwool

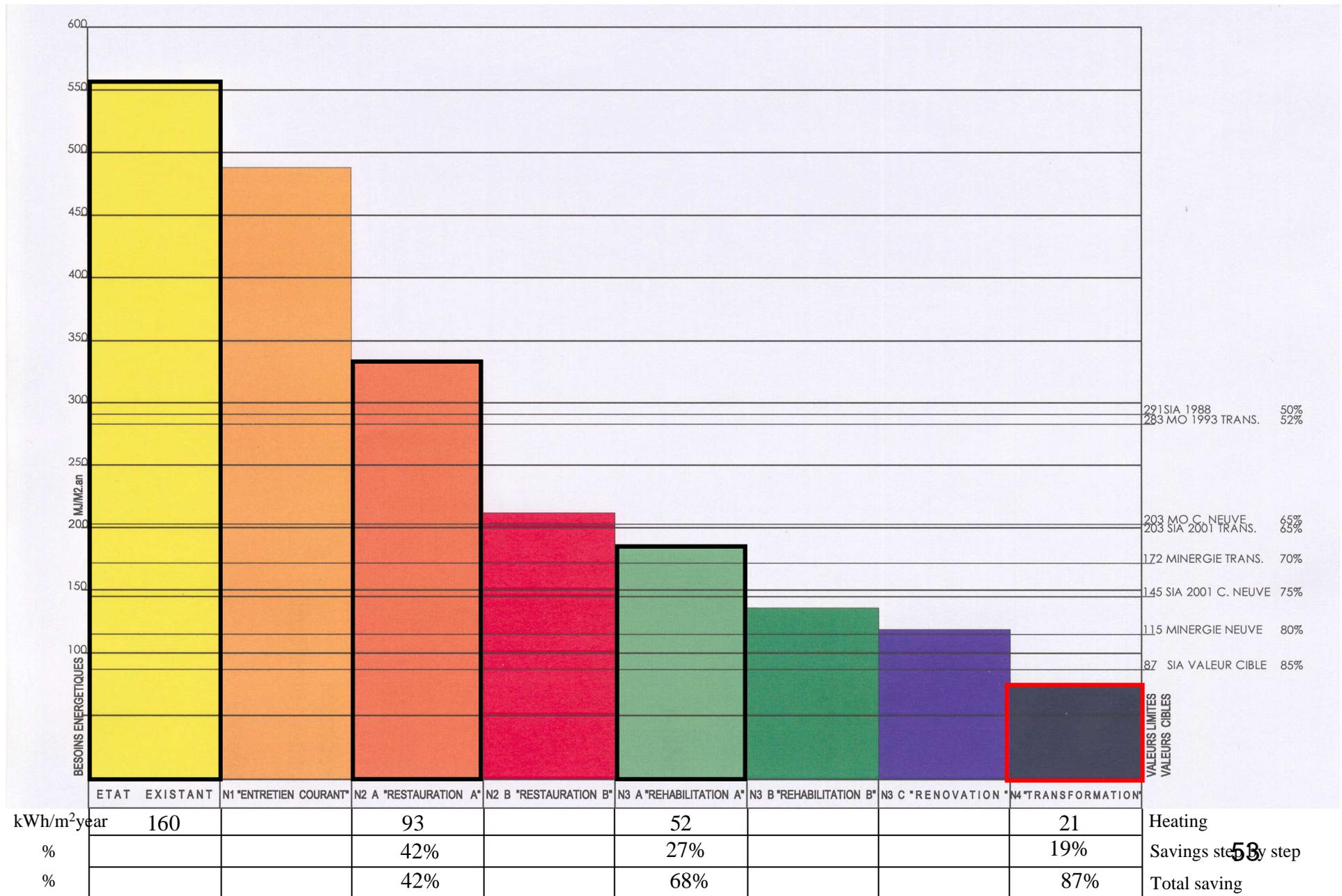
Basement: same as restoration

Insulation



5. Type 3 / Renovation at boulevard Carl-Vogt

SUMMARY OF SIMULATIONS



Type 3 / RENOVATION AT BOULEVARD CARL-VOGT

CONCLUSION

The detailed study of the existing building, based on simulations, with thermal improvements based on technical existing solutions, has shown that:

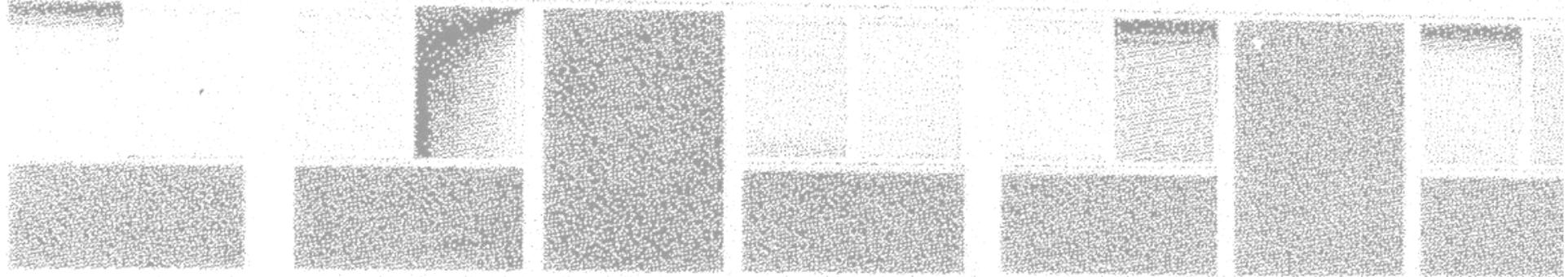
- A "rehabilitation", with a minimum of interventions (strengthening of existing insulation, punctual insulation ground floor when needed and improvement of glazing as required by the law), has already a significant effect close to 40% energy saving.
- A "renovation" with additional savings of what was done in rehabilitation (the replacement of existing glazing by high insulating glazing, and internal insulation of the envelope), allows the economy of almost three quarters of the heating energy. Well below the label "Minergie transformation 2002" for the quality of the envelope and the heating demand.
- Finally, the "transformation" (that includes an important external insulation, 12 cm), can reduce over 80% energy consumption and meet the requirements of the "2000W" society¹, without the installation of a double-flow ventilation. But this solution is not accepted for a protected building, the change of the look and concept of the facade, makes it difficult to accept this transformation.

We see that careful "renovation" is able to reduce drastically the energy consumption without altering the architectural quality of the building.

Finally external insulation is only reducing 11% due to already good U value of the walls with internal insulation and also due to the relatively low surface of the walls (45% of façade)

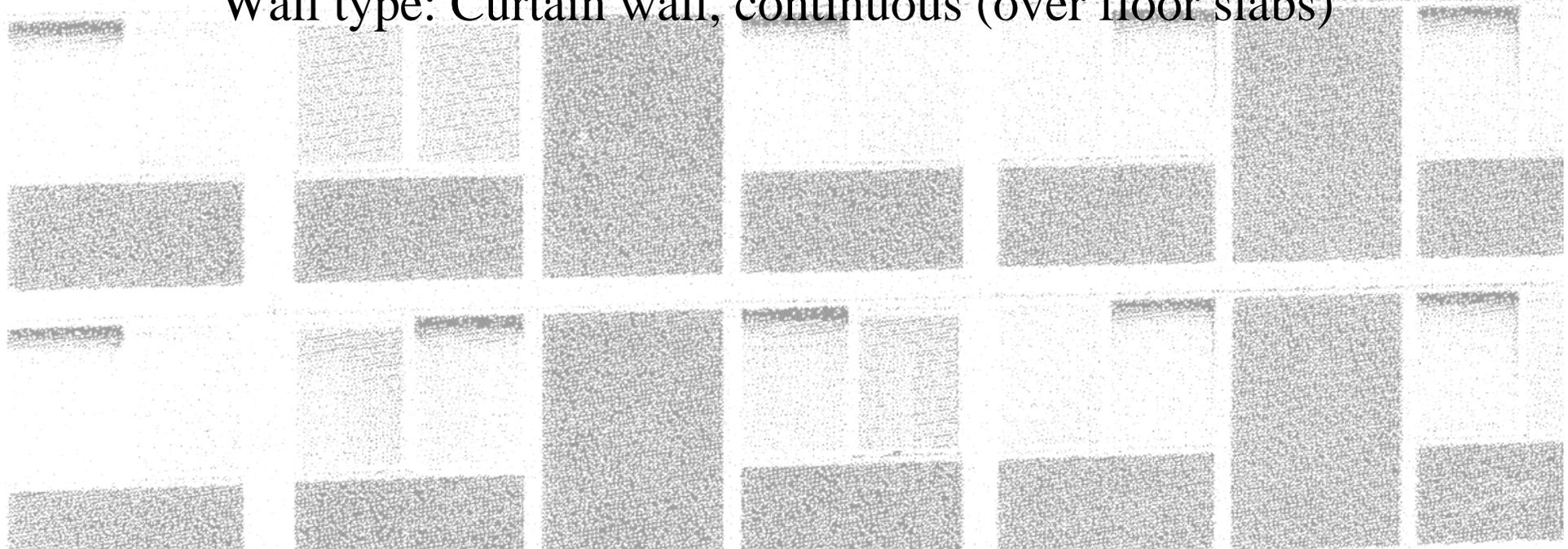
¹ A person needs 17,500 kilowatt-hours a year on global average of the world. This corresponds to a continuous requirement of 2000 watts. The vision of a 2000-Watt society enables a balance between industrialized and developing countries and thus makes it possible for all people to enjoy a good standard of living. For Switzerland, it means to divide by 3 his consumption.

6. Type 4 / Le Lignon – thermal improvement of the envelope



6. Type 4 / Le Lignon - thermal improvement of the envelope

Wall type: Curtain wall, continuous (over floor slabs)



6. Type 4 / Le Lignon – thermal improvement of the envelope

SUMMARY

Built between 1964 and 1967 « La Cité du Lignon », with its 2780 apartments and 10 thousand inhabitants, was a response to the increase in population of Geneva. The Lignon includes two twin towers of 31 floors and one building of nearly one kilometre long. The centre of the plot is dedicated to public activities. Le Lignon is a protected zone since 2009.

Today the buildings are more than 40 years old and call for a rehabilitation / renovation, including improvements of the thermal envelope.

Therefore, the “Office des Monuments et Sites”, jointly with the “Service cantonal de l’énergie” and the “Comité central du Lignon”, asked the University of Geneva and the Ecole polytechnique of Lausanne to explore solutions to be applied to all the buildings of the “Cité du Lignon” that are able to preserve the unity of this complex and its architectural qualities.

Owner	Private and public
Architects	Addor, Julliard and Bolliger
Construction	1964 -1967
Renovation	Preliminary expertise, test apartments 2010
Built volume	N° 22 2919 m ²

Energy index

- before renovation 122 kWh/m²an
- after renovation 53 kWh/m²an (simulation)

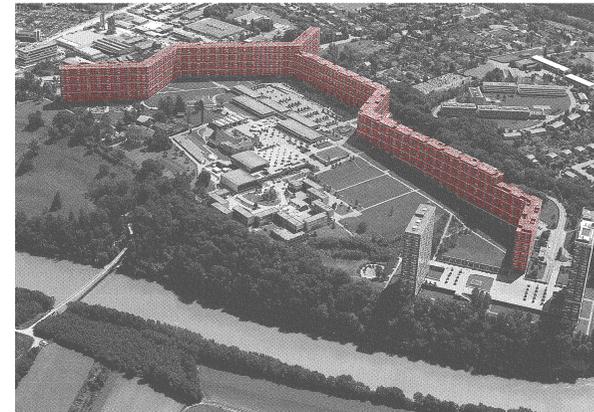
Description

Insulation over basement and roof. New windows. Internal insulation of the wall. Controlled ventilation.

Information sources:

Werk 5, 1969, Uberbauung Lignon Genf

Cité du Lignon, Rapport concernant l’amélioration thermique, Olivier Barde, 1981



6. Type 4 / Le Lignon – thermal improvement of the envelope

LIGNON, A PROTECTED ZONE

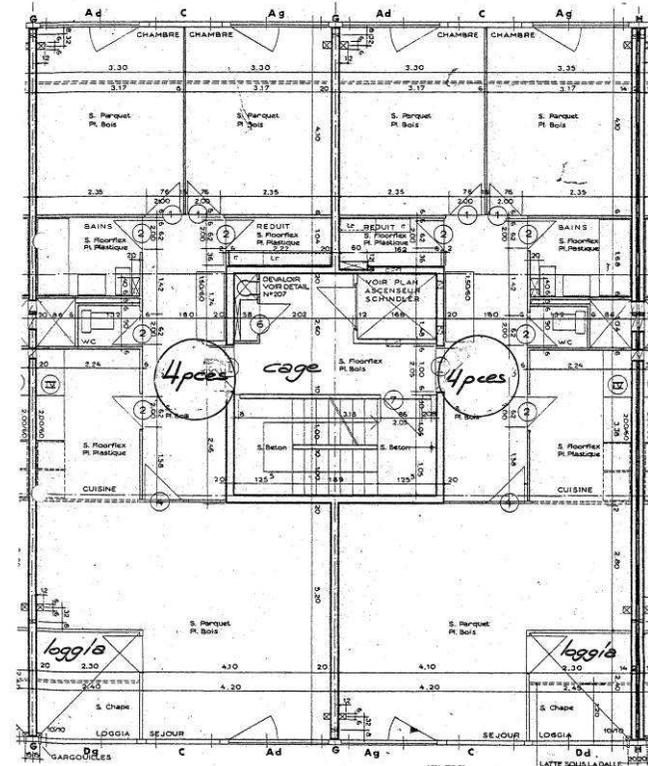
The site of Le Lignon has been classified in 2009. The Statements for the protection of the Cité du Lignon are as follows: « *These apartment buildings, two towers and one “Y” shaped building are remarkably well integrated in the landscape and therefore are a block of buildings of great value. The housing development of exceptional dimensions is a model for the architecture of the sixties in Geneva and even in Europe....* »



6. Type 4 / Le Lignon – thermal improvement of the envelope



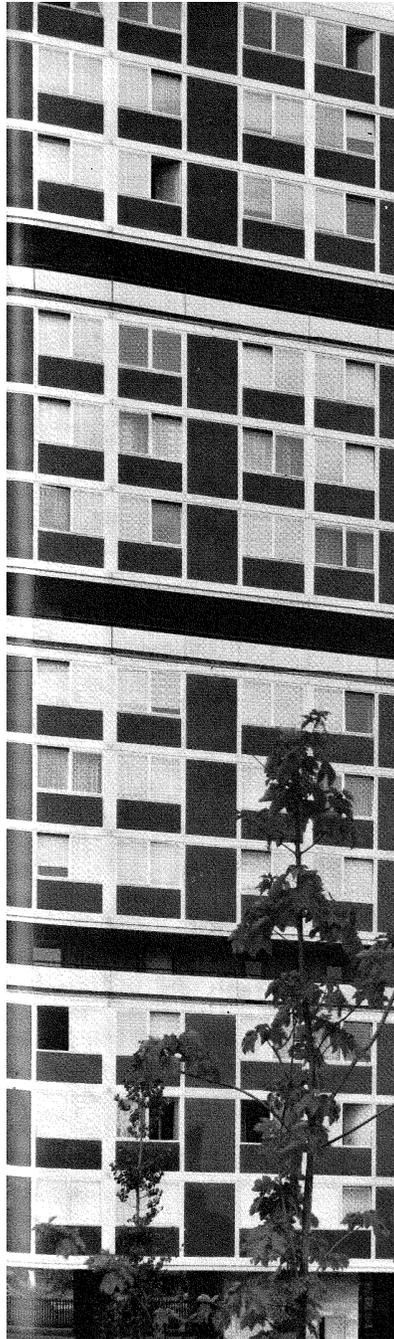
General view



Typical plan



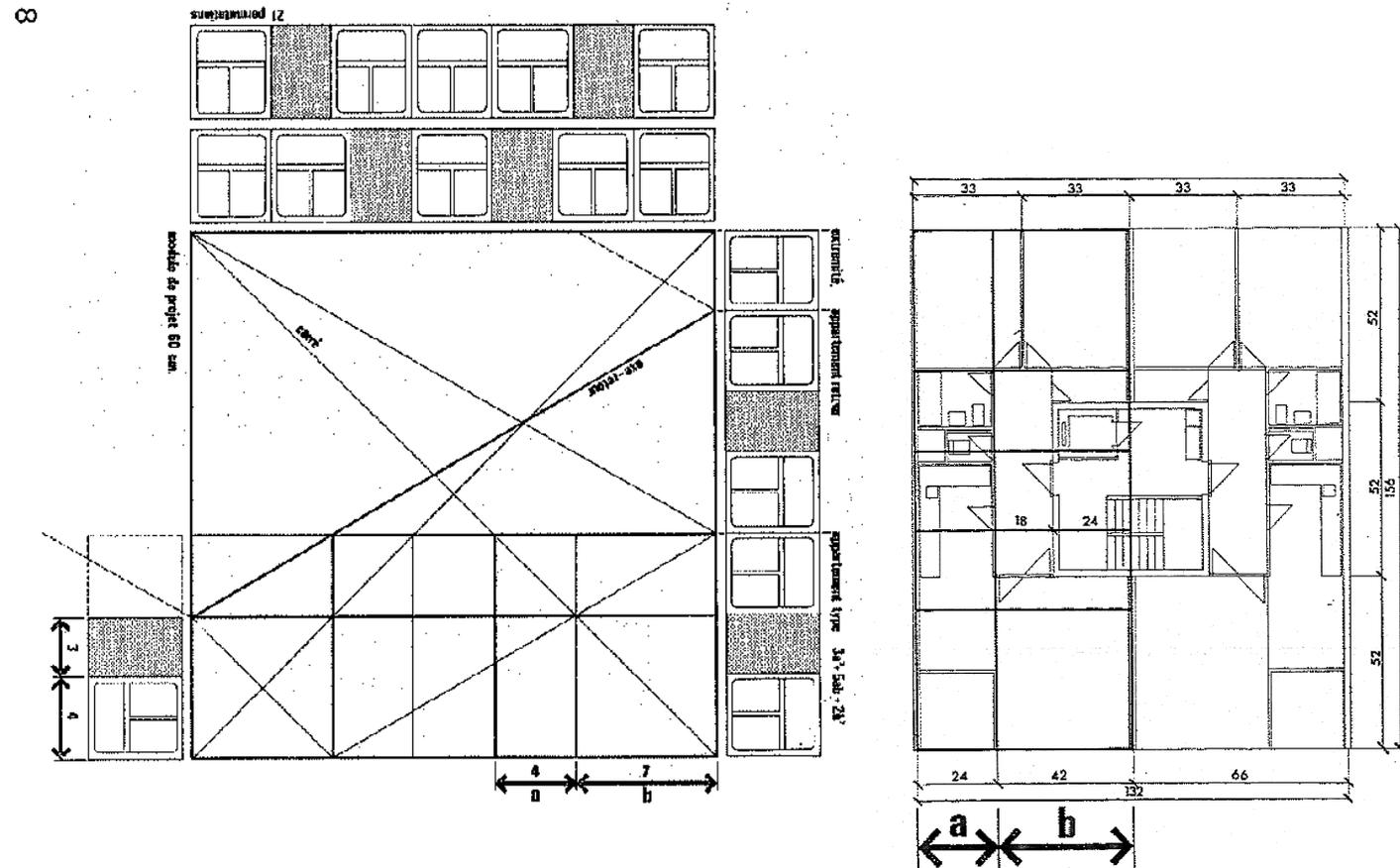
6. Type 4 / Le Lignon – thermal improvement of the envelope



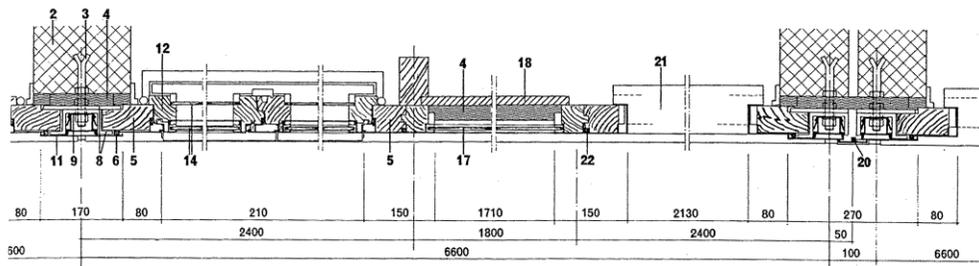
SIMULATION

Based on a detailed analysis of the existing energy consumption, simulations will evaluate thermal improvements of various interventions on the envelope, based on existing technical solutions: insulation of roof and basement, new windows and internal insulations.

The clever design of the plan and the use of a modular system enabled to reduced the façade elements to 2 types in order to facilitate the prefabrication.

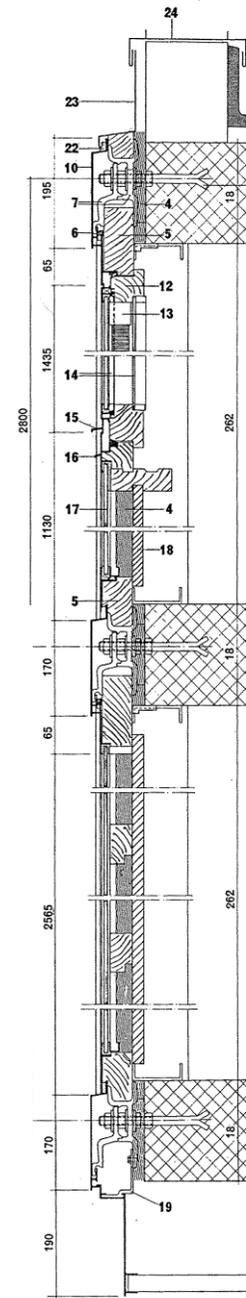
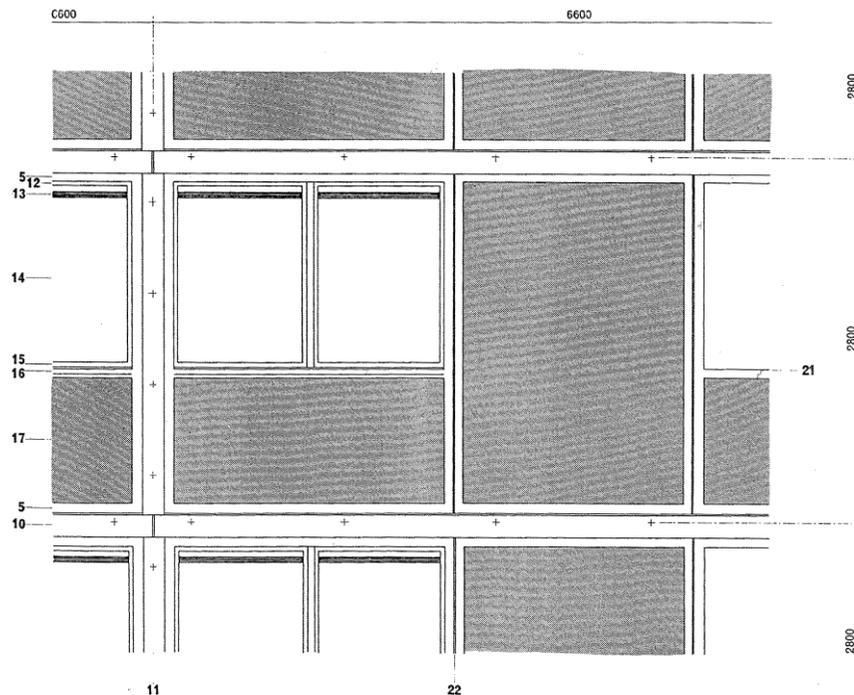


6. Type 4 / Le Lignon – thermal improvement of the envelope



Details of the facade, plan, section

- | | |
|------------------------------|--------------------|
| 1 Concrete slab | 12 Window frame |
| 2 Concrete wall | 13 Venetian blinds |
| 4 Insulation | 14 double glazing |
| 5 Part of the window frame | 17 Enamelled glass |
| 10 Cover profile (aluminium) | 18 Wooden board |

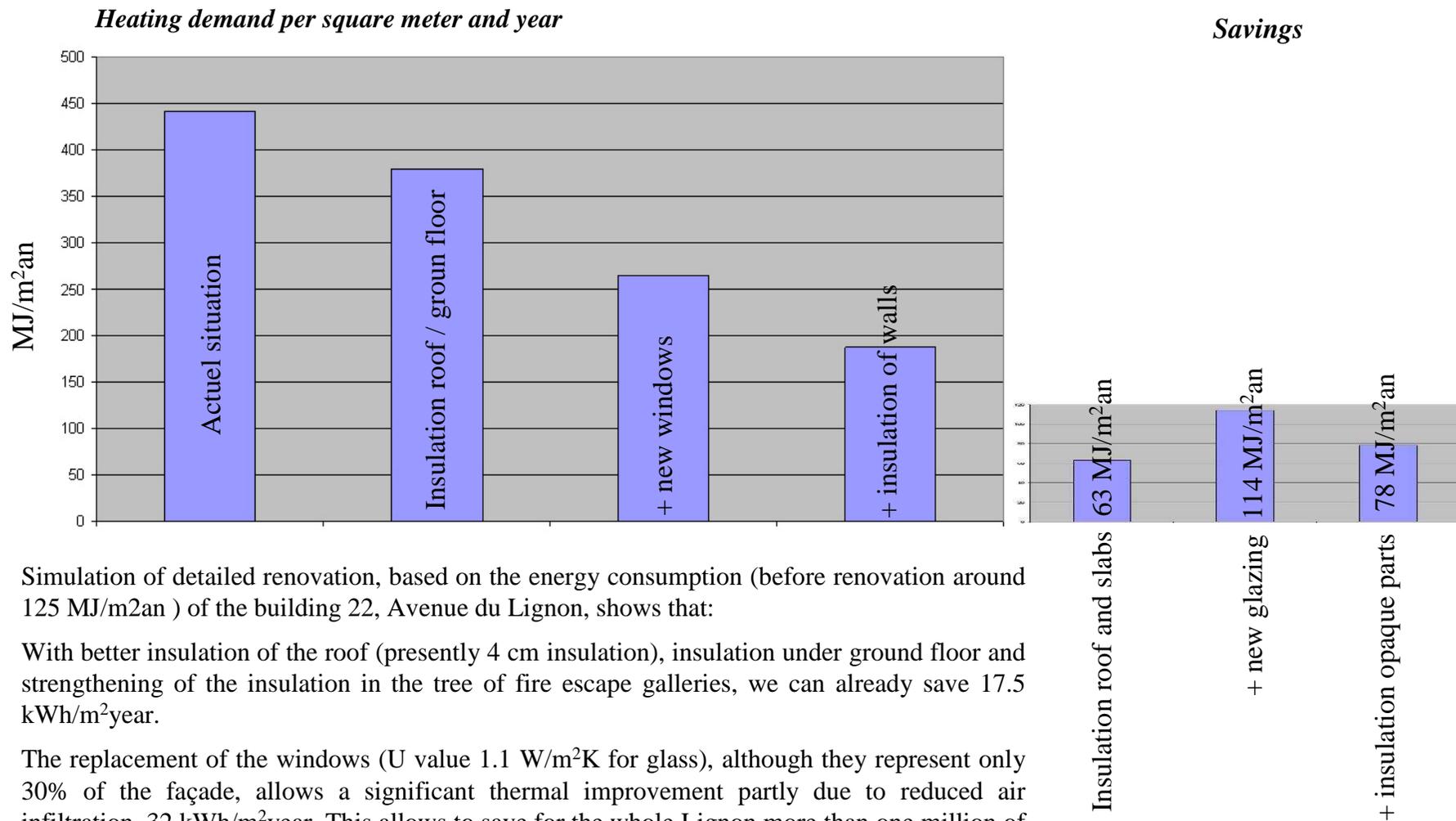


The combination metal-wood for the achievement of the façade was chosen:

- Aluminium, for the durability, its resistance to weather and for its lack of maintenance.
- Wood for its good thermal insulation and comfort.

The high number of such façade elements required to carefully develop construction principles and details. Tests of strength, stability, sealing and ease of assembly contributed to the choice of the final details. The façade elements are fixed in the head of the wall by staples ensuring a quick and easy construction.

LE LIGNON / CONCLUSIONS



Simulation of detailed renovation, based on the energy consumption (before renovation around 125 MJ/m²an) of the building 22, Avenue du Lignon, shows that:

With better insulation of the roof (presently 4 cm insulation), insulation under ground floor and strengthening of the insulation in the tree of fire escape galleries, we can already save 17.5 kWh/m²year.

The replacement of the windows (U value 1.1 W/m²K for glass), although they represent only 30% of the façade, allows a significant thermal improvement partly due to reduced air infiltration, 32 kWh/m²year. This allows to save for the whole Lignon more than one million of litres of oil.

With inner insulation of the walls, we gain another 22 kWh/m²year.

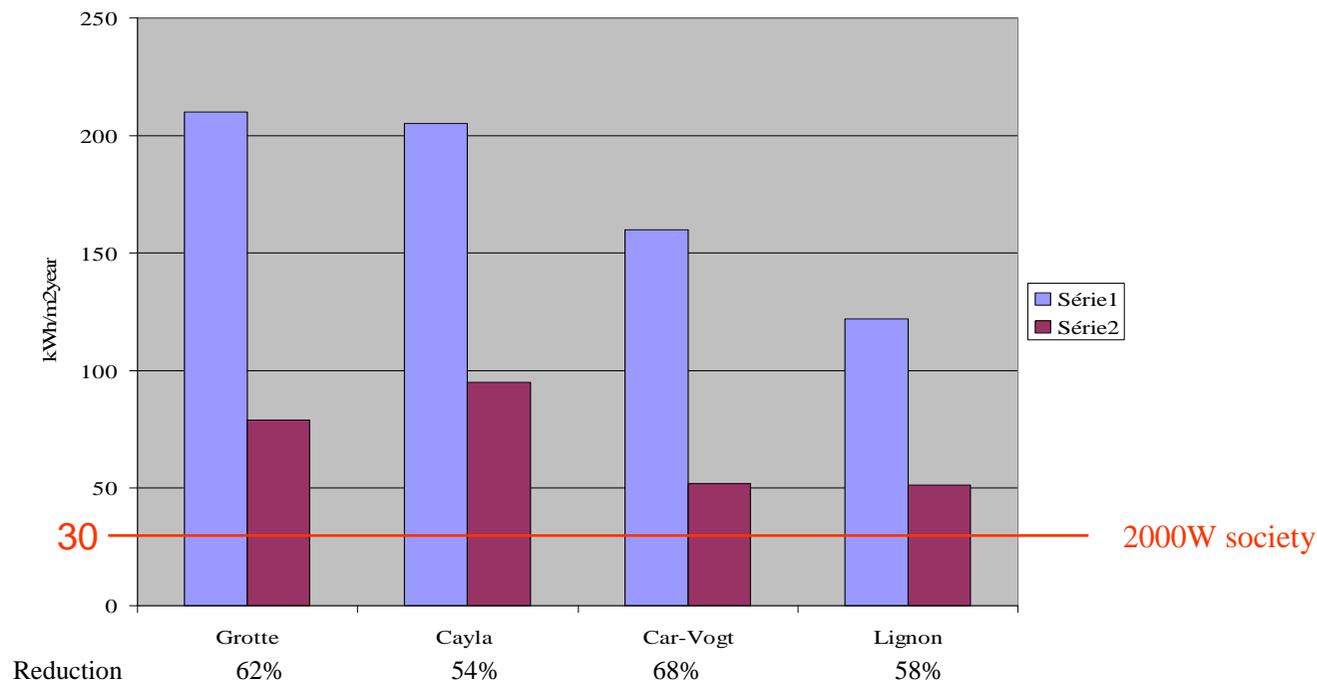
The assumption of external insulation was eliminated by the owners because of the complexity and the high cost of this solution:

- necessity of scaffoldings (15 and 33 floors)
- need to empty at least a part of the building (no tenant).

Conclusion

The number of analysed buildings should be increased in order to be able to have a consistent overview . But already with these four buildings, representing the main typologies, we can make some statements about the lowering of the energy demand for heating in protected buildings and about the limiting factors for insulation:

Lowering of heating demand



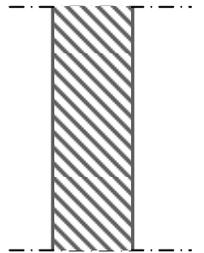
Even for protected buildings, a careful “renovation” is able to reduce drastically the energy consumption without altering the architectural quality of the building.

But lowering energy consumption of protected and historical buildings to the level of the 2000W society is still difficult and will need special technical improvements, for example:

- Implementation of the double flux ventilation (like 20 rue des Grottes), in general very difficult and expensive to implement in existing building (lowering the energy consumption around 10 to 12 kWh/m²/year).
- Vacuum insulation panels would be an adapted solution when by inner construction 40 to 50 % of the space can be saved ¹. These panels need a careful detailed planning and are not yet commonly used by building contractors.

¹ Gregor Steinke, Armin Binz, Bausystem mit VIP – Hinterlüftete Fassaden und innendämmung, Status Seminar 2008, pp 275-282

Innovative or especially effective improvements



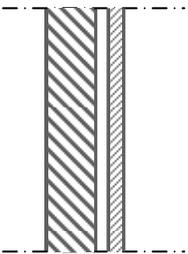
Distributed insulation



Type 1
20, rue des Grottes
Building 1870
Renovation 2002

For Rue des Grottes:

- The insulating stucco, because of the large surface of the walls, has a important effect on energy consumption and comfort.
- Double-flow ventilation with heat recovery (10% savings) and solar water storage are located on the top floor under the roof with central gas heating (near the solar collector and saving of air ducts).



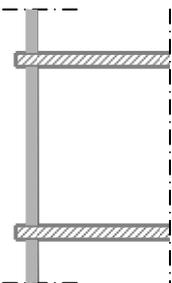
Internal doubling



Type 2
Cayla towers
Building 1954
Renovation 2002

For Cayla:

- The opportunity to compare energy savings and architectural impact on scale 1/1 with two identical buildings improved with internal and external insulation is quite exceptional.



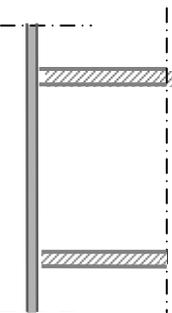
Filling between walls and slabs



Type 3
Boulevard Carl-Vogt
Building 1962
Renovation in preparation

For Car-Vogt building:

- The exploration, step by step of increasing improvements of the envelop, in order to observe the impact on the architectural aspect of the building and the energy savings.
- Work with a team of architects and engineers specialized in façade improvement.



Curtain wall before walls and slabs

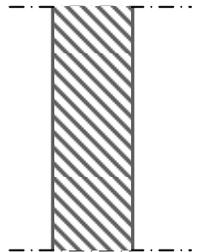


Type 4
Cité du Lignon
Building 1964-67
Renovation 2010

For the Lignon:

The scale of the building (3700 apartments and today 7000 inhabitants) and the limited types of components of the façade requires a careful analyse and verification with prototypes in order to be able to apply the chosen solution on all the buildings and insure the foreseen energy savings (more than one million litres of oil).

Limiting factors for wall insulation



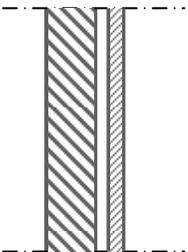
Distributed insulation



Type 1
 20, rue des Grottes
 Building 1870
 Renovation 2002

Buildings with massive masonry :

- Risks of moisture at the head of the beams of the floors.
- Embrasures of windows that limit the thickness of wall insulating rendering and cause thermal bridges.
- Massive stone walls that must remain visible.



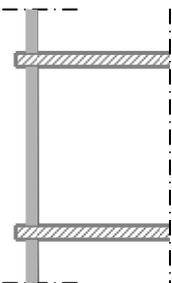
Internal doubling



Type 2
 Cayla towers
 Building 1954
 Renovation 2002

The limiting factors of Cayla are:

- The « historical value imperatives » limit the thickness of the external thermal wall insulation in order to maintain the proportions of the different elements constituting the complex architectural expression of the façade.
- Internal insulation is limited by the very small surface of the apartment and can not avoid all the thermal bridges



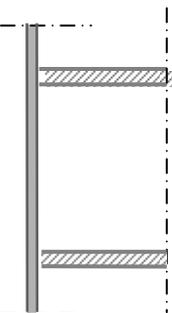
Filling between walls and slabs



Type 3
 Boulevard Carl-Vogt
 Building 1962
 Renovation in preparation

For Car-Vogt building:

- External insulation changes the look of the building, and thickens architecture details.
- Available space in the balconies is diminished.
- The important proportion of windows (over 30%) makes it more difficult to apply external insulation.



Curtain wall before walls and slabs



Type 4
 Cité du Lignon
 Building 1964-67
 Renovation 2010

For the Lignon:

This typology avoids the important thermal bridges at the head of walls and slabs. External insulation is quite easy to apply. Limiting factors are:

- Necessity of scaffoldings (15 and 33 floors).
- Need to empty at least a part of the building (no tenant) that implies costs.

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