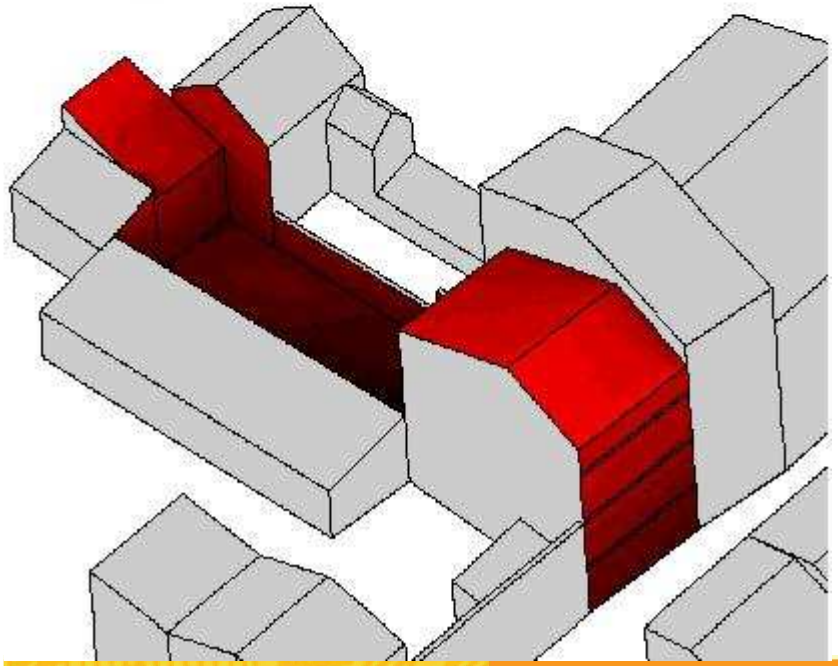

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DIAGNOSTICS AND IMPROVEMENT OF THE ENERGY EFFICIENCY OF CULTURAL HERITAGE BUILDINGS

Examples of towns with protected areas of the ANVPAH & VSSP

UNDP – International Conference « Energy Management in cultural heritage »
Croatia, Dubrovnik – 6-8 april, 2011

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The ANVPAH & VSSP

- Network bringing together 170 towns and regions which bear the label « Town and region of art and history », have a protected sector or architectural heritage protection zones.

- Exchange platform developing programmes and issues relating to energy requirements of built heritage, taking into account quality of life, social mixity and mobility issues

- A wide partnership :
  - Ministry of culture and communication,
  - Ministry of Ecology, sustainable development, transports and housing
  - The Caisse des Dépôts
  - Ministry of foreign and european affairs

- An international cooperation platform : Eastern Europe, Mali, India

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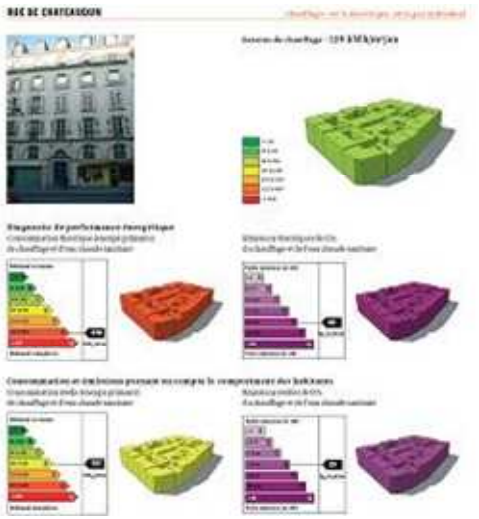
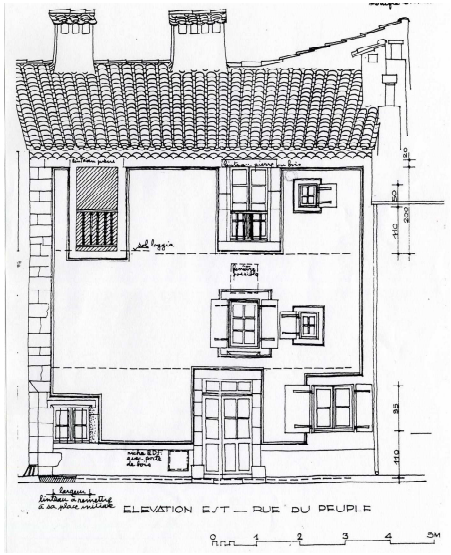
Workshop « Cultural heritage and sustainable development »

- Partership with the Caisse des Dépôts since 2007
  - Exchange platform : workshops, reflection days, training and technical seminars, assessments and visits to members'towns who request it

- Partnership with the technical service of the MEEDDT : the CETE de l'Est
  - Guidelines and specifications for local authorities who want to make an energy audit of an old protected area

Guide pour les villes souhaitant réaliser un audit énergétique de leur patrimoine bâti ancien





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CETE Est

association nationale

Knowing before acts : key elements

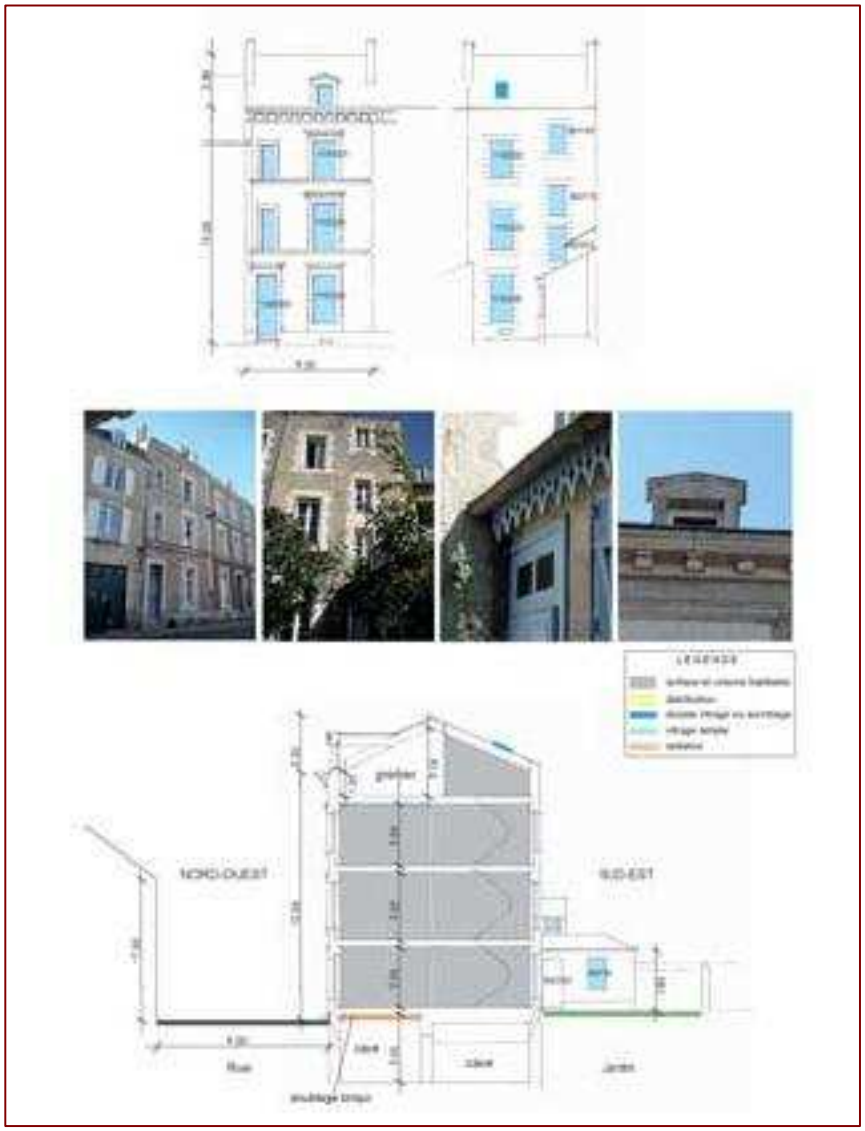
- Architectural knowledge of buidings :
  - Environment : climatology, sun hiding, …
  - Urban morphologies
  - Construction systems
  - Materials

  → Doing a global study at the scale of old centre

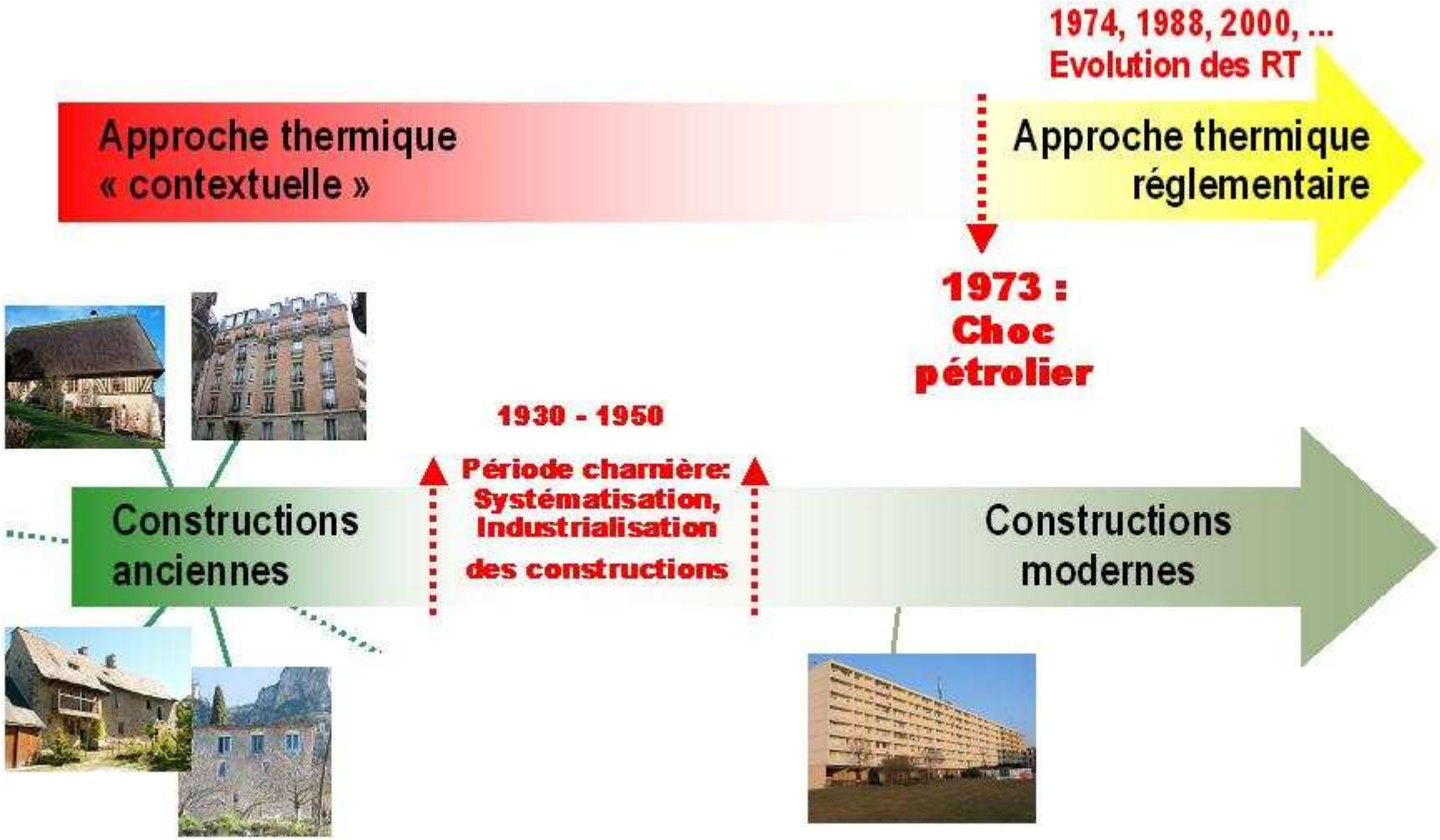
- Thermical and hygrometrical comportment :
  - Analyses of lived housing
  - Analysing theoric results with real consumptions in order to make them reliable

Differents steps of study

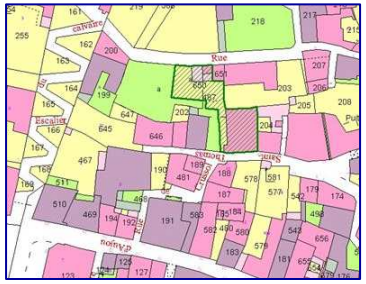
- Thermical typology
- Collecting real data in buildings
- Analysis/diagnosis
- Making calculations
- Elaborating proposals
- Possible followings



Typology : how studying cultural heritage building from the point of view of energy efficiency ?



Phase 0: First work with municipality

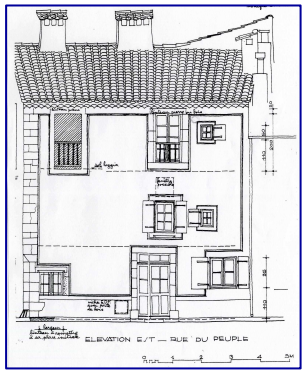


Municipality must use its existing documents

- Heritage urban plan and prescriptions
- Architectural files on protected area, ZPPAUP, etc.

Preliminary works facilate the study :

- Architectural typology (implantation, materials...)
- Checking out potential buildings to test (available bills, voluntary inhabitants)



→Translate architectural vision into thermical vision

Ex : City of Saintes

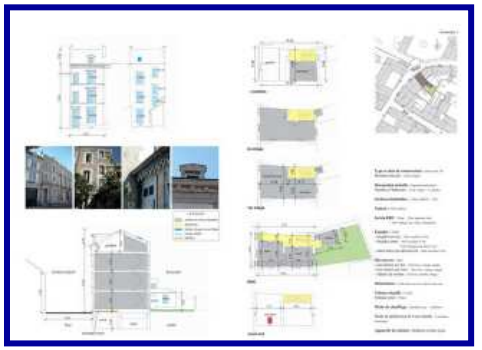
Phase 1: definition of a thermical typology

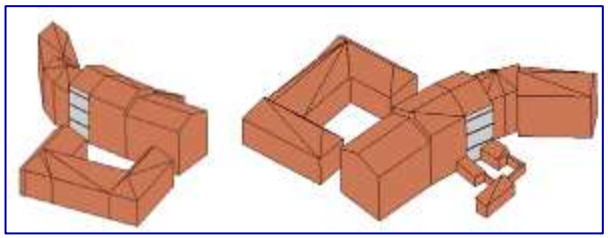
Several parameters affect thermical comportment of a housing

- Types of materials, of glazing
- Type of implantation (density of constructions...)
- Construction systems

... And the choice of the test building :

- housings open to technicians
- Known energy consumptions





Ex : City of Poitiers

Phase 1: Pictures of studied towns

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Ex : Cities of Saintes, Grenoble, Poitiers, Nantes, Bayonne

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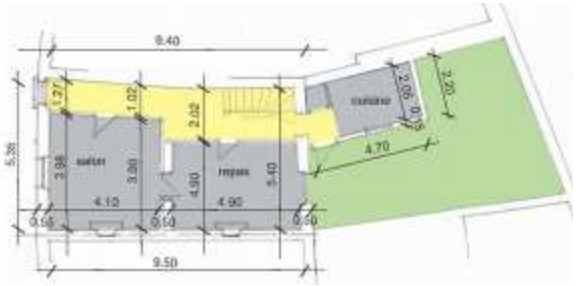
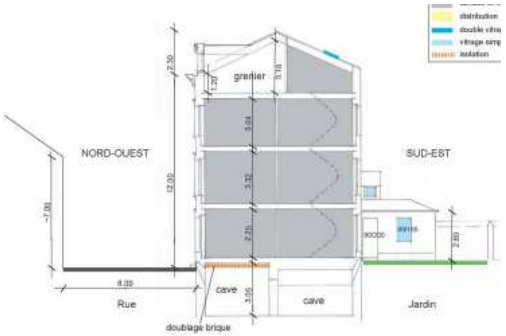
Phase 2: Statements and measures on the ground



Plans and section of the building



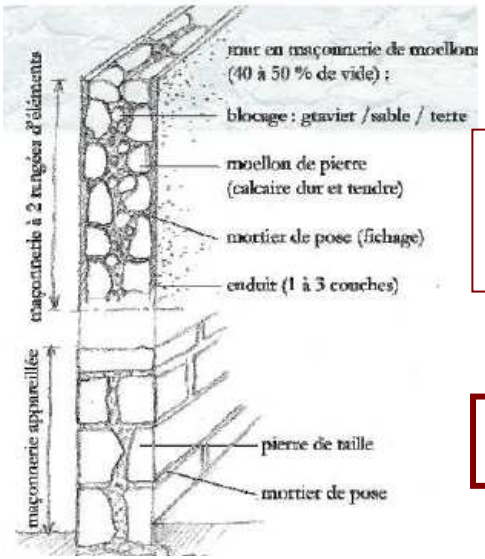
Ex : Poitiers

Equipements et systems + energy bills

Ex : Nantes

Implantation

Ex: Bayonne



Construction systems

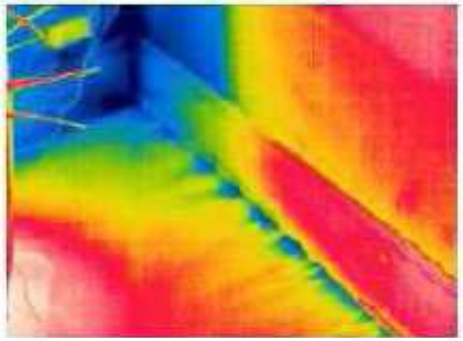
Ex : Grenoble

Phase 2: Statements and measures in situ

- Tools to know better the building :

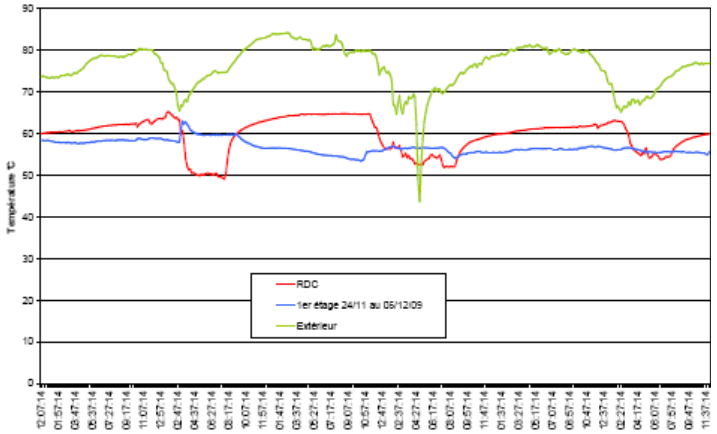
Thermal imaging IR

Ex : City de Grenoble



Measures of t°

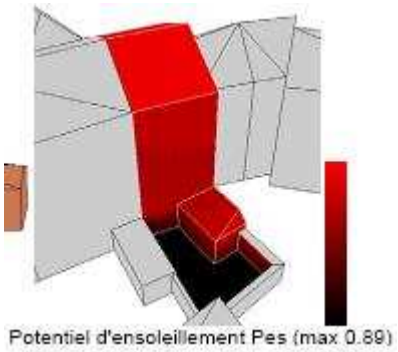
Ex : City of Saintes



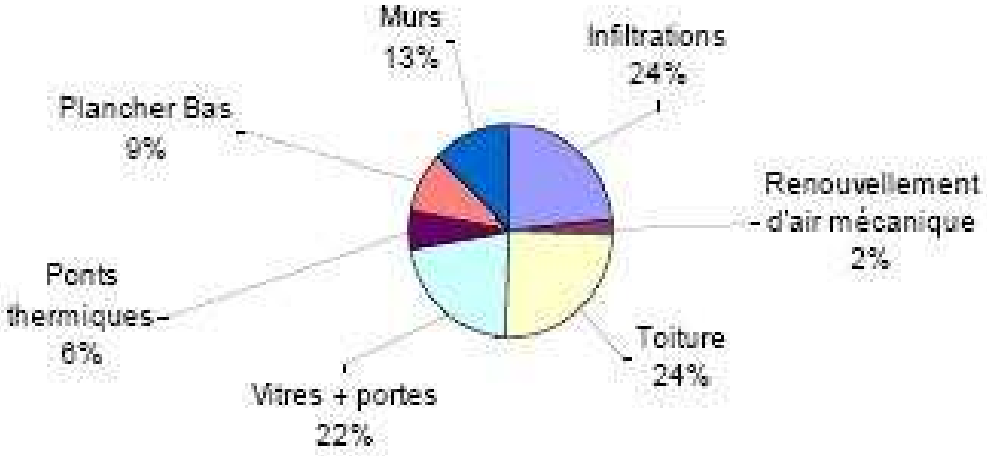
Tests of air permeability on housings

Phase 3 : Diagnosis of existing building

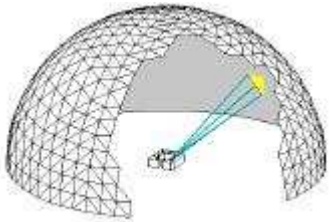
- Analysing the environment :



calculation of energy losses



Work on sunshining



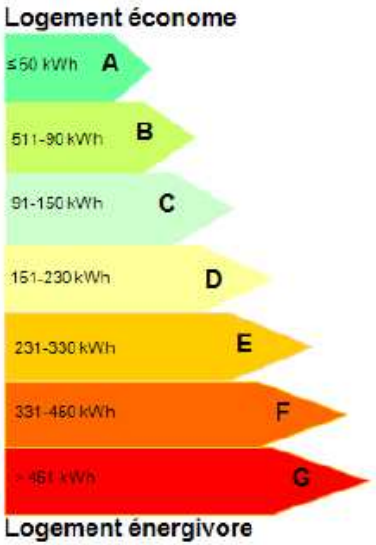
Ex : City of Poitiers

Ex : Cities of Saintes, Nantes

Phase 3 : Diagnosis of existing building

Possibility of obtaining a first photography of the initial thermical state :

Consommation kWh/an/m² qui inclus chauffage / ECS et usages domestiques (éclairage, appareils, etc…)



Ex : City of Grenoble

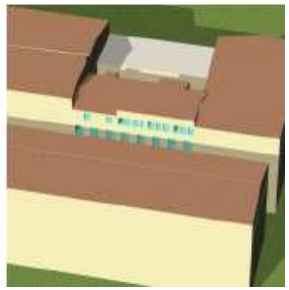
Phase 4 :Calculations and simulation of solutions

When we use a software, it's necessary to calibrate the mathematic model of the initial building with real bills.

	Conso réelle C kWh	Besoins calculé STD kWh	Consommation calculée STD kWh	Ecart conso réelle/STD
Appart Loose	11267	10118	12647	12%
Appart Samson	15526	13141	16426	6%
Appart Huet	6150	5988	7485	21%
Appart Jaussoin	32759	24181	36637	12%
Appart Boutry	3179	3650	3650	15%
Appart Raynaud	4540	6225	6225	37%

Ex : Grenoble

The use of a software of dynamic thermical simulation is largely advised in order to know real comportment of old buildings



Example of softwares : Comfie-Pléiades, Trnsys, TAS... At least 5 000 € / building

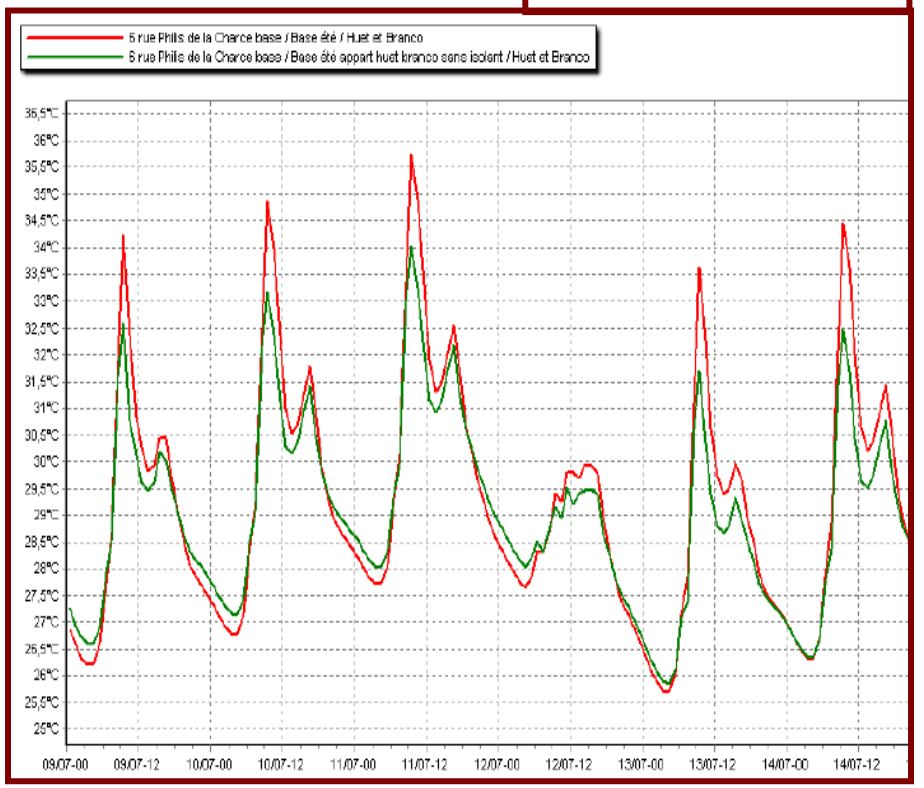
Phase 4 :Calculations and simulation of solutions

Several acceptable tests in order to study :

- thermical efficiency and thermical comfort
- heritage and architectural issues
- humidity migration
- global cost

Example of lime and hemp plaster in 3 layers

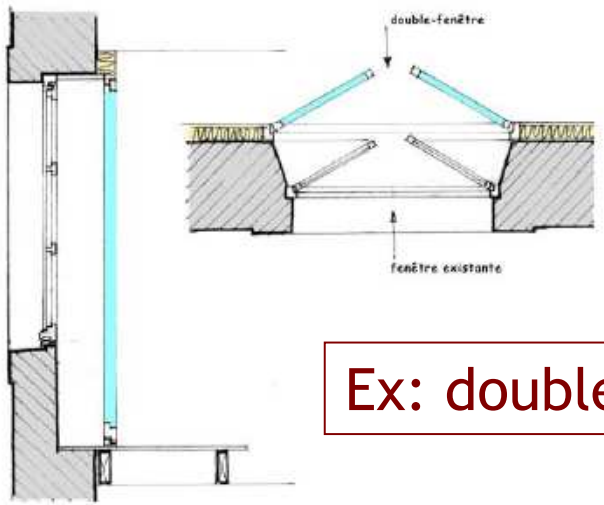
Ex : Grenoble



Phase 5 : Proposals of thermical rehabilitation

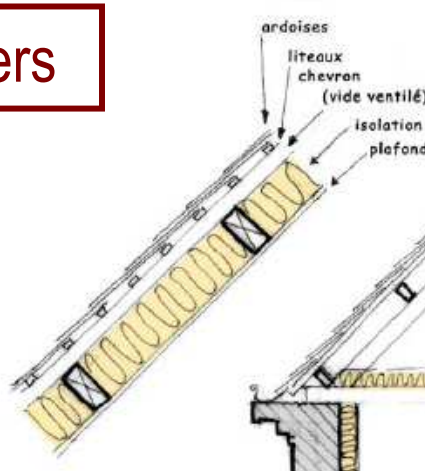
Impacts of several solutions

n°		Propositions	Cep total	CepCH	Cep ECS	Cep ELEC	Δ en %	Δ en kWhep/m²SHON
0	base	base	144	112	21	11	0,0%	0
1	BATI	Murs ITE cour 200mm R=5	135	103	21	11	6%	9
2	BATI	Murs ITI partout 100mm sur ossature R=3,15	113	82	21	10	21%	31
3	BATI	Murs isolés partout 4cm chaux/chanvre λ=0,042	124	92	21	11	14%	20
4	BATI	Baies BOIS DV Uw=1,40 partout + gain étanchéité	132	100	21	11	9%	13
5	BATI	Baies BOIS DV Uw=1,40 sur cour + gain étanchéité	139	107	21	11	4%	5



Ex: double-window

Ex : City of Poitiers



Phase 5 : Proposals of thermical rehabilitation

Ex: implementation of a insulating mineral lime plaster (Unilit 20, λ=0,066W/m.K)

Thickness (in cm)	1 cm	2 cm	3 cm	4 cm	5 cm
Savings on annual heating consumption (%)	10 %	19 %	26 %	30 %	34 %

Ex : City of Grenoble

Lime plaster cost 5 cm (HT) = 90€/m2 + scaffolding 25€/m2

Annual consumption before plaster = 105 kWh_{ef} /m²/an and after works: 70kWh_{ef} /m²/year

Annual energy gain for a housing of 100 m² = 230-350 € depends on heating mode

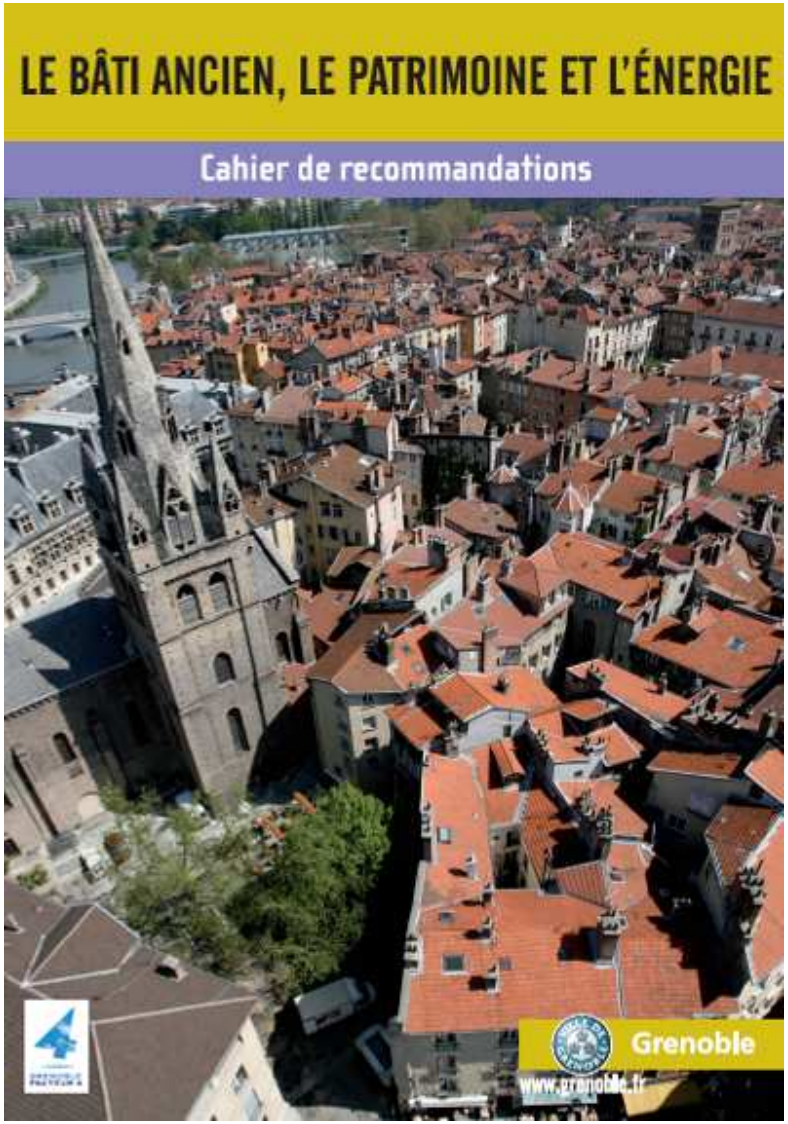
Phase 6 : Transfering knowledges

- Realising guidelines
- Transfering knowledges in order to raise awareness among all the local actors involved in energy rehabilitation (contracting authorities, private investors, social landlords, heritage architects, engineering departments, artisans, etc.) on these issues
- National and international exchanges with others municipalities and actors

Guidelines of Poitiers

- 3 studies of pratical cases
- Summing up sheets with proposal of solutions
- Pros and cons of the works types recommanding
- 10 worksheets permiting energy savings and comfort for inhabitants :
  - low floor insulation
  - roofs insulation
  - walls insulation
  - windows restoration or replacement
  - veranda creation
  - heating and DHW systems replacement
  - solar systems
  - energy control systems
  - ventilation system
  - improving natural and artificial lighting

Guidelines of Grenoble



Guidelines gives heritage regulations, technicals solutions, costs, schemes, and possible energy gains for several items :

- Walls
- Roofs
- Low floor
- Windows
- Heating systme
- Ventilation
- Solar energy

Guidelines of Grenoble

- Architectural styles of every periods

The Middle Ages and the Renaissance

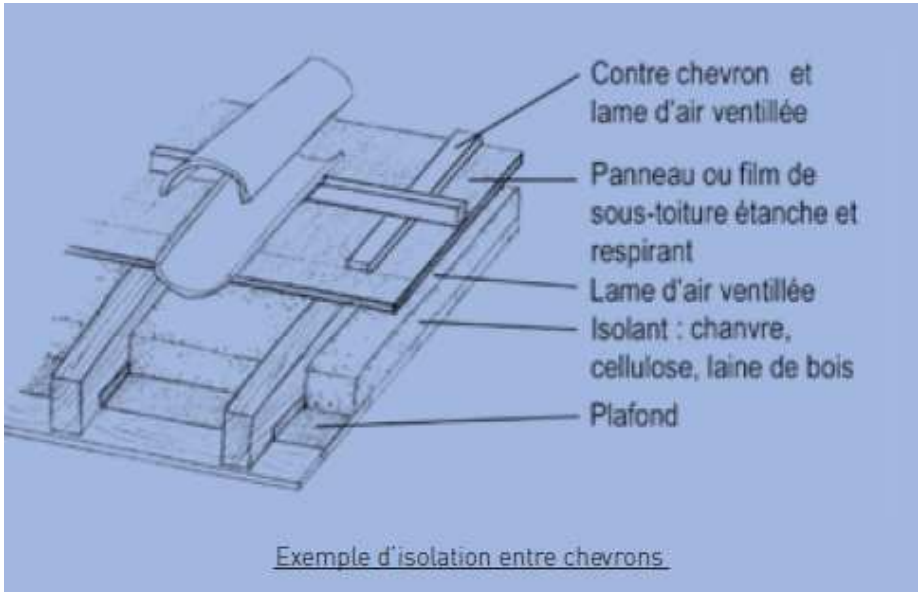
The XVIIth century

The XVIIIth century

The XIXth century and hausmannian style

Guidelines of Grenoble

- Examples : roofs



Exemple d'isolation entre chevrons

Occupation	Combles non aménagés	Combles aménagés
Isolants	Isolant minéral (laine de verre ou de roche) ou végétal (laine de bois, chanvre...), cellulose...	
Mise en œuvre	• Pose de l'isolant sur le plancher, en rouleaux ou par insufflation.	• Panneaux semi-rigides ou rigides posés en sous-face de la toiture, sous et entre les chevrons.
Coût indicatif HT	20 €/m² pour 20 cm de laine de roche.	42 à 60 €/m² pour 20 à 30 cm d'isolant (hors doublage de finition).
Gain énergétique indicatif	50 % (pour le dernier étage)	

Guidelines of Grenoble

- Advised insulating materials

Matériaux	Exemples de produits	Conductivité thermique lambda (λ)*, en W/m. K
Isolant pour plancher bas	• Béton de chanvre • Vermiculite, perlite • Liège	0,11 0,068 0,04
Enduit à caractère isolant pour l'intérieur et l'extérieur	• Enduit chaux silice expansée	0,066
Enduit à caractère isolant pour l'intérieur seul	• Enduit chaux chanvre	0,12 à 0,17
Isolant rigide en plaque minérale	• Béton cellulaire	0,04
Isolant semi-rigide	• Laine de bois • Laine de chanvre • Cellulose	0,038 à 0,04
Simple vitrage épais isolant		U** = 3,2 à 3,4 W/m².K

→ the smaller lambda is, the bigger insulation is

Experimental works in Bayonne

- A global study with a heating ingeneer and a architect

→ Building in the old centre with a timbered and stone front.

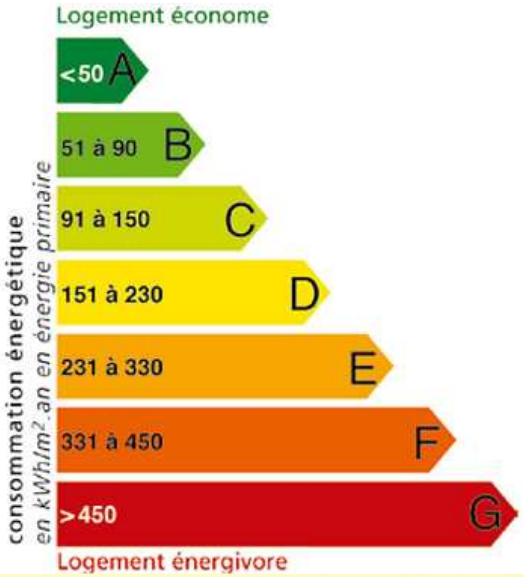
→ Choice of the co-ownership : **200 € /m² (+10 %)**

- Timbered front : hemp panels + hollow brick
- Stone front : coated hemp
- ceiling insulation : 300 mm of wood wool
- Double windows, (interior double glazing)
- shared gas heating (low-temperature)
- DHW : individual electric
- Ventilation system : dual flow

➔ **final energy efficiency : 42 kWh/m²/an (B)**

➔ low-power building (label BBC)
French buildings standards for rehabilitation : 80 kWh/m²/an

Initial energy efficiency : 220 kWh/m²/an



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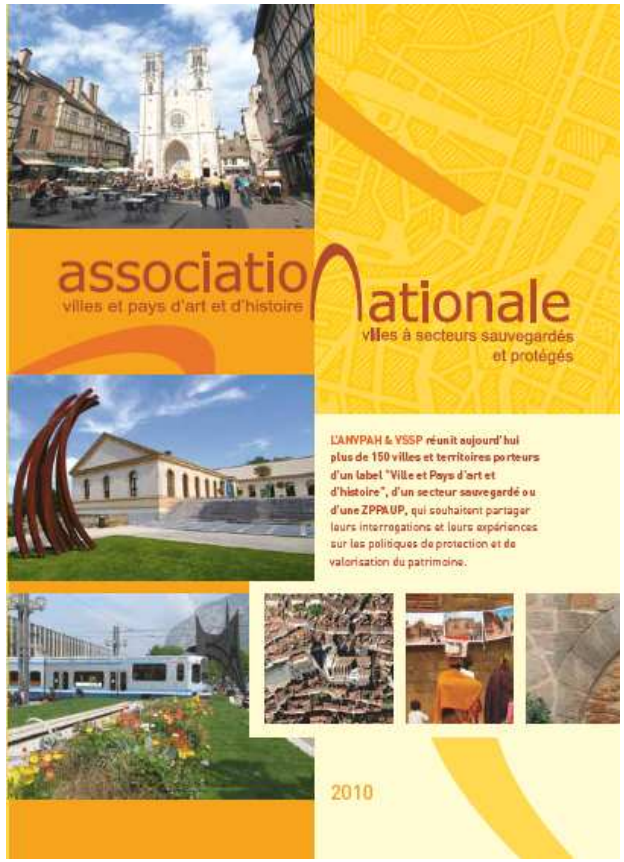

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