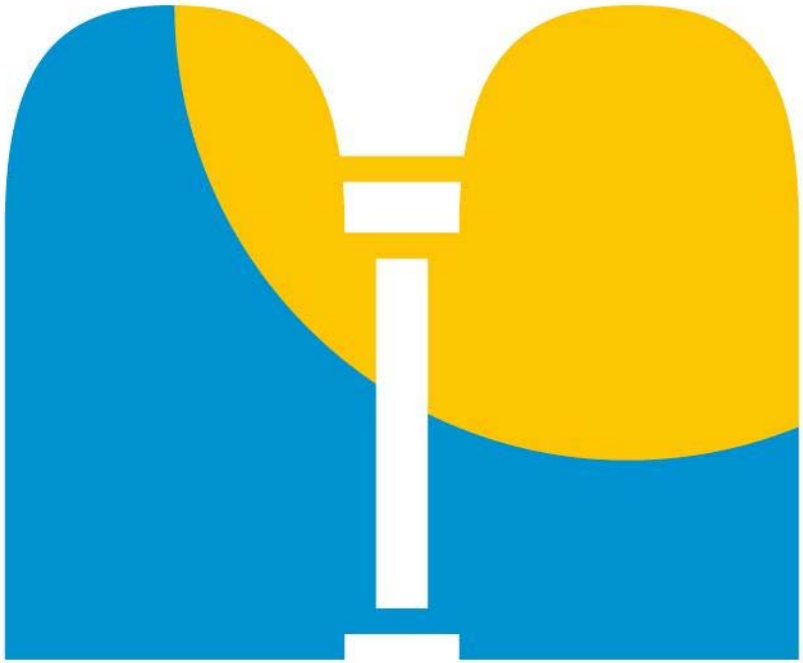

D8.9 Educational Material for University Studies

Innovative concepts for energy saving refurbishment in historic buildings

Alexandra Troi, EURAC research

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 260162

Guiding principle

Presentation 2

Author: Alexandra Troi

Partner: EURAC research (EURAC)

University course: Darmstädter Ingenieurkongress - Bau und Umwelt

Date: 12-13.03.2013

Place: Technische Universität Darmstadt, Fachbereich Bauingenieurwesen und Geodäsie

Title of the lesson: “Innovative Konzepte der energetischen Sanierung im Baudenkmal“

Description of the contents: The energy requirement of a historic building can be substantially reduced finding the right solutions and implementing the high quality. This is the guiding principle in the European research project 3ENCULT "Efficient Energy for EU Cultural Heritage": for the energy retrofit of a historic building the multidisciplinary exchange between all stakeholders starts with a comprehensive diagnosis of the status quo, supports the development of solutions and selection of the most appropriate one, and does not end before an integrated monitoring and control, which verifies and guarantees performance. Methods to be applied include (i) conservation inventory system (as e.g. “Raumbuch”) which are further developed in order to well interface with energy issues, but also (ii) conservation related non or minor destructive testing (NDT) technologies (as e.g. IR-thermography, ground penetrating radar, ultrasonic tests) as well as (iii) energy performance related diagnosis (as e.g. again IR-thermography, blower door test, heat flow measurements). Also, the works work done in the Waaghaus in Bozen and in the Höttinger Schule in Innsbruck are presented. The works regard internal insulation, replacement of windows, air tightness, moisture at beam ends, ventilation, air flow balancing, daylight and artificial lighting optimisation.

Name of the files: WP8_D8.9_20131007_EURAC-Lesson 1 en and WP8_D8.9_20131007_EURAC-Lesson 1 de

Guiding principle

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Also in historic buildings the energy demand can be reduced considerably – if an interdisciplinary team looks for the right solutions for the specific building and implements them with high quality.

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From diagnosis to monitoring of success

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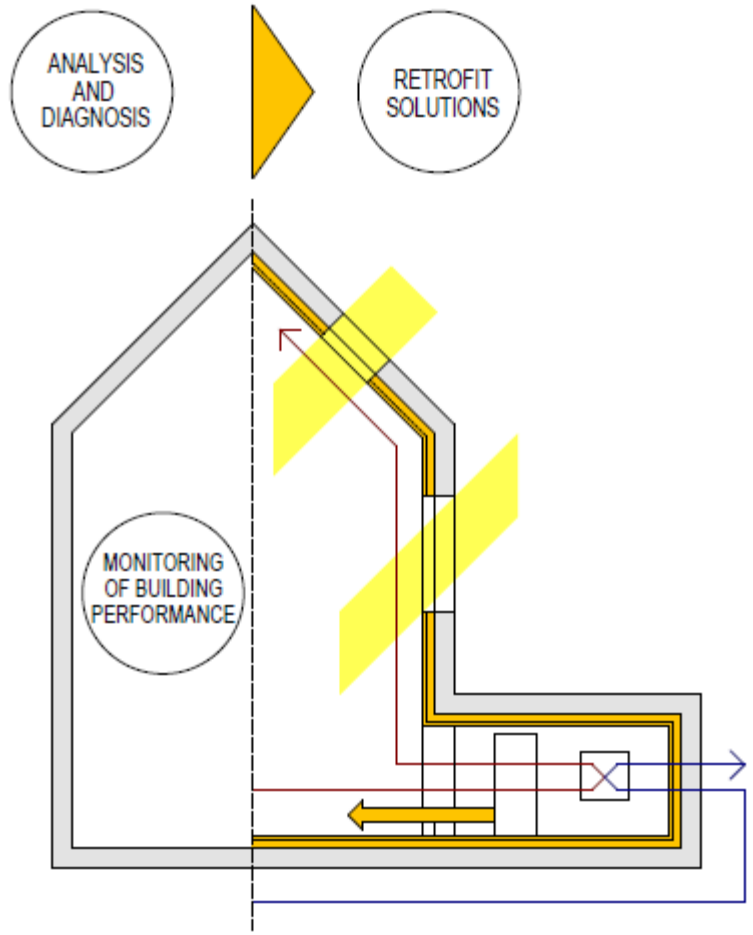

- Diagnosis
  - Conservation value
  - Potential damage
  - Energy related aspects
- Design
  - Looking at the building as a whole
- Documentation & monitoring

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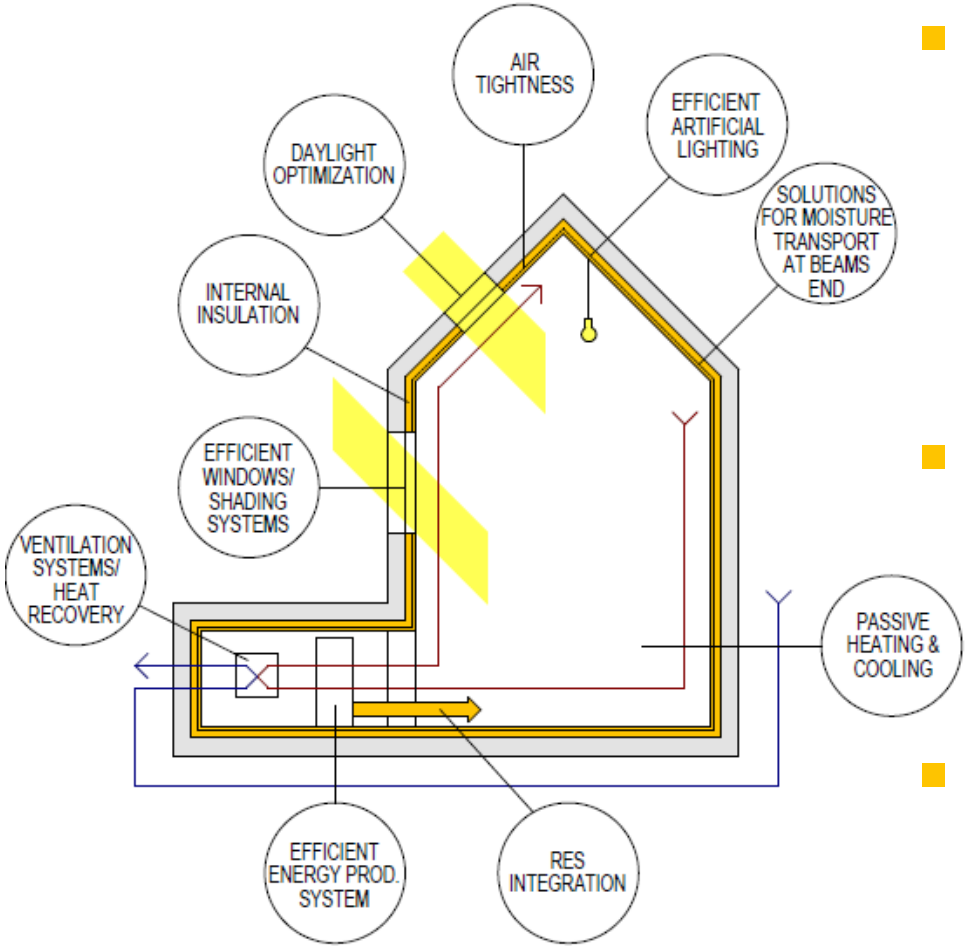
Planning with a view to the **entire building**



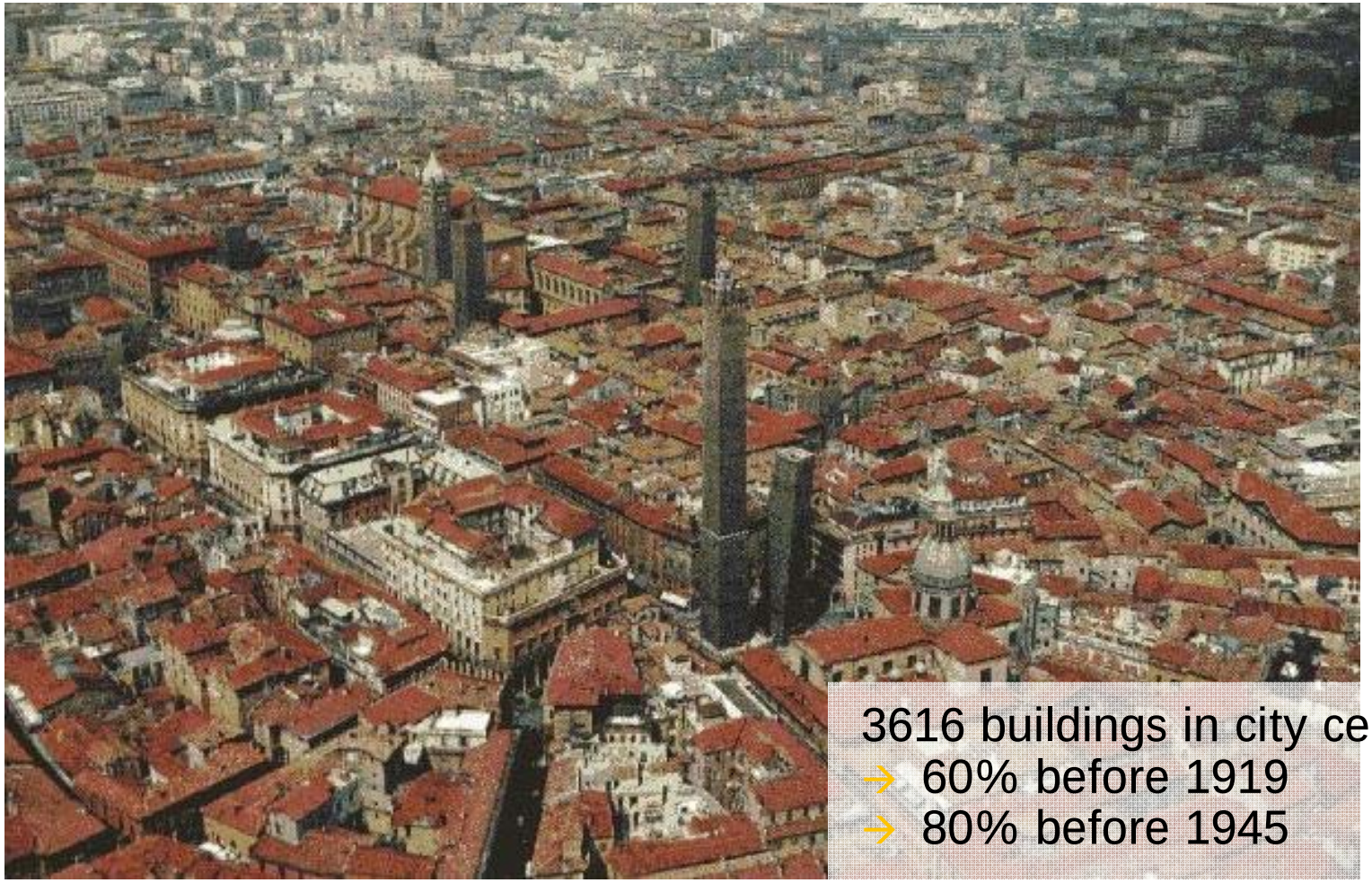
- Diagnosis
  - Conservation value
  - Potential damage
  - Energy related aspects
- Design
  - Looking at the building as a whole
- Documentation & monitoring

Denmark

- 9,000 buildings in Denmark are listed (as the best or most characteristic of their type and period)
- 300,000 buildings have been assessed to be worthy of preservation.

→ SAVE project: documentation of buildings built before 1940

Bologna



3616 buildings in city centre
- → 60% before 1919
- → 80% before 1945

Work in a interdisciplinary team

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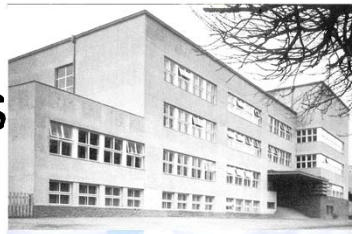
				Role			
			Case study	"Technical solutions"	"Urban context"	"Conser-vation"	"Dissemi-nation"
EURAC research	IT	Coordinator, WP1 & WP8 lead	x	x			
The Royal Danish Academy of Fine Arts	DK	WP2 lead	x		x		
IDK - Institut für Diagnostik & Konservierung an Denkmalen	DE	WP2 co-lead				x	
Universität Innsbruck	AT	WP3 lead	x	x			
ARUP	UK	WP3 co-lead		x			
Universität Stuttgart	DE	WP4 lead	x	x			
Cartif	ES	WP4 co-lead	x	x			
Bartenbach Lichtlabor	AT	WP5 lead		x			
TU Dresden	DE	WP6 lead	x				
Institute for Building Climatology				x			
Chair for Historic Preservation & Building Research						x	
Centre of Expertise in Urban					x		
Comune di Bologna	IT	WP6 co-lead	x		x		
Passivhaus Institut	DE	WP7 lead		x			
TNO	NL	WP7 co-lead					x
Alma Mater Studiorum Università di Bologna	IT	diagnosis & monitoring	x				
DICAM						x	
DIES				x			
Artemis	IT	diagnosis & monitoring				x	
Grupo Unisolar	ES	solar solutions		x			
Menuseries Andre	FR	window solutions		x			
Remmers	DE	insulation solutions		x			
ATREA s.r.o.	CZ	ventilation solutions		x			
youris.com	BE	dissemination					x
ICLEI Europe	DE	dissemination			x		x
REHVA	BE	dissemination					x

EURAC research

Case studies Overview

- 8 case studies
  - Waaghaus, Bozen/Italy
  - Palazzo d'Accurso, Bologna/Italy
  - Palazzina della Viola, Bologna/Italy
  - Arsenal, Kopenhagen/Denmark
  - Höttinger School, Innsbruck/ Austria
  - Speicherstadt, Potsdam/Germany
  - University building, Bejar-Salamanca/Spain
  - Strickbau, Appenzell/Switzerland



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Dialogue and develop together

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“Raumbuch” integrated with energy issues

- Monuments are unique → any change has to be prepared by a **comprehensive analysis**
  - information to the **historic** materials and constructions,
  - potential existing **damages** as well as
  - strong and weak points from **energy** perspective
- Collect and **visualize** in a structured way any information needed for the diagnosis (descriptions, plans, photographs, drawings of details, results of non or minor destructive testing, monitoring data as well as calculations and models).
- Architects, conservators and engineers
  → **“move” through** the building on different levels of detail
  → information for constructive discussion **at their hands**.

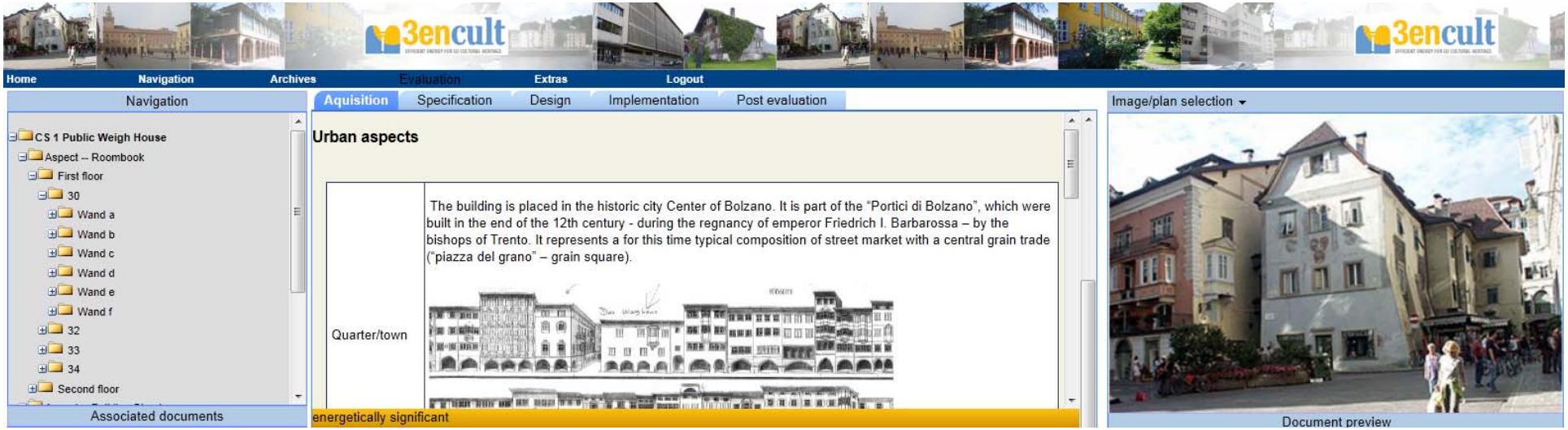
“Raumbuch” integrated with energy issues

Usefulness goes beyond diagnosis!

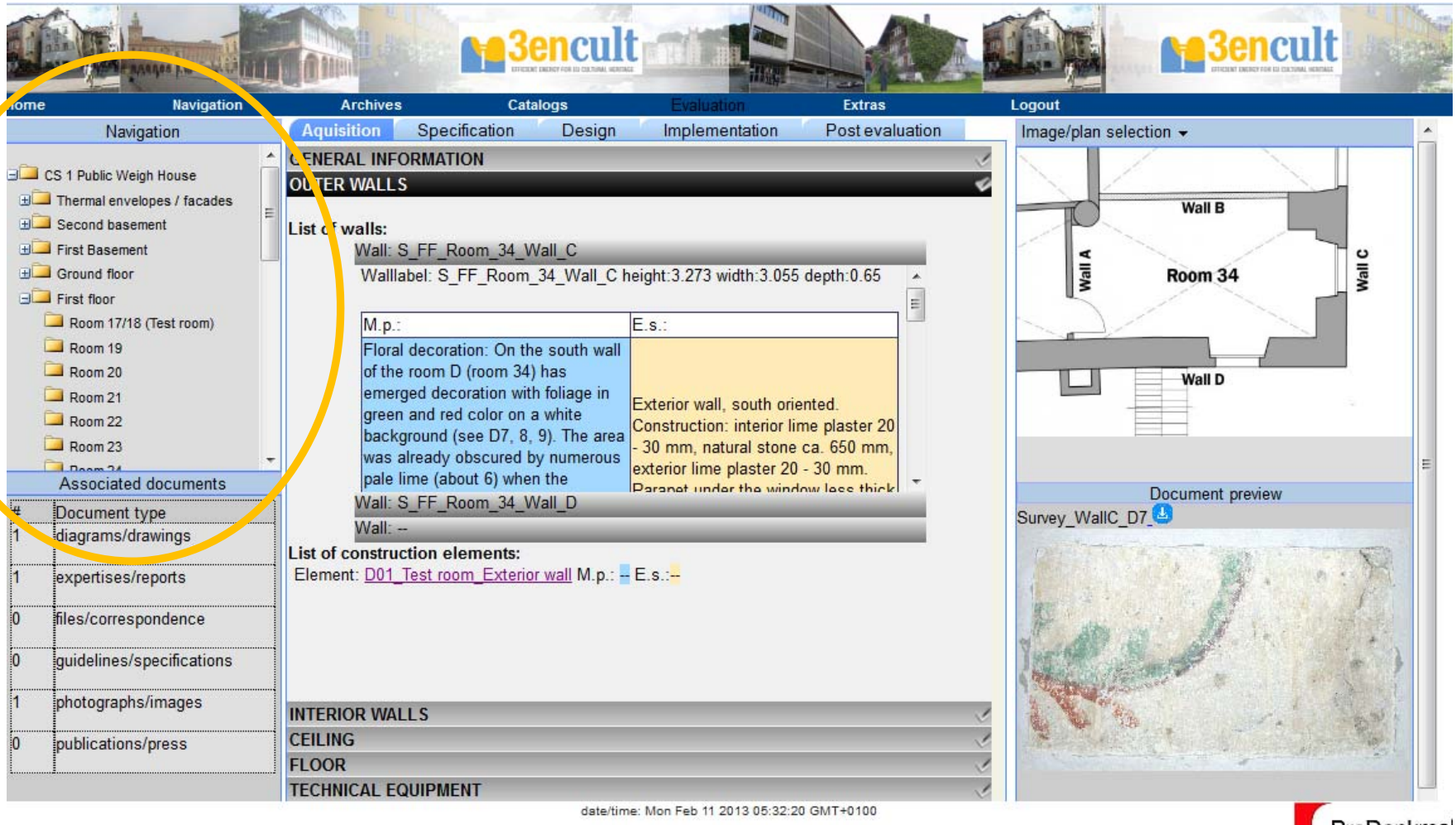
- development of solutions,
- comparison of different options
- selection of the best one for the specific building

will profit from the

- structured presentation and
- simultaneous look at both conservation and energy aspects
- not only on an aggregated level, but down till the single room.



Navigation structure



ProDenkmal
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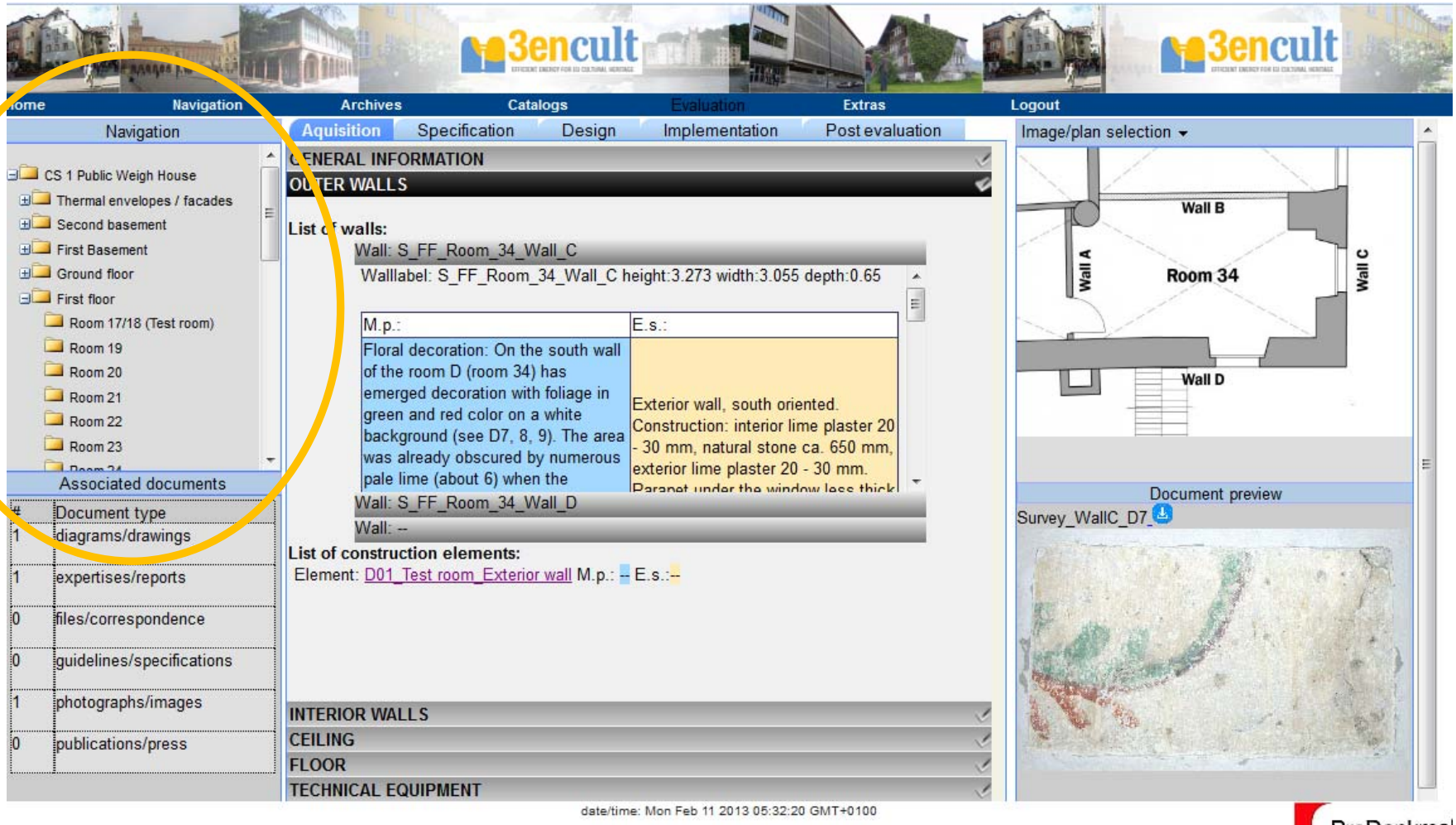
Navigation structure



ProDenkmal
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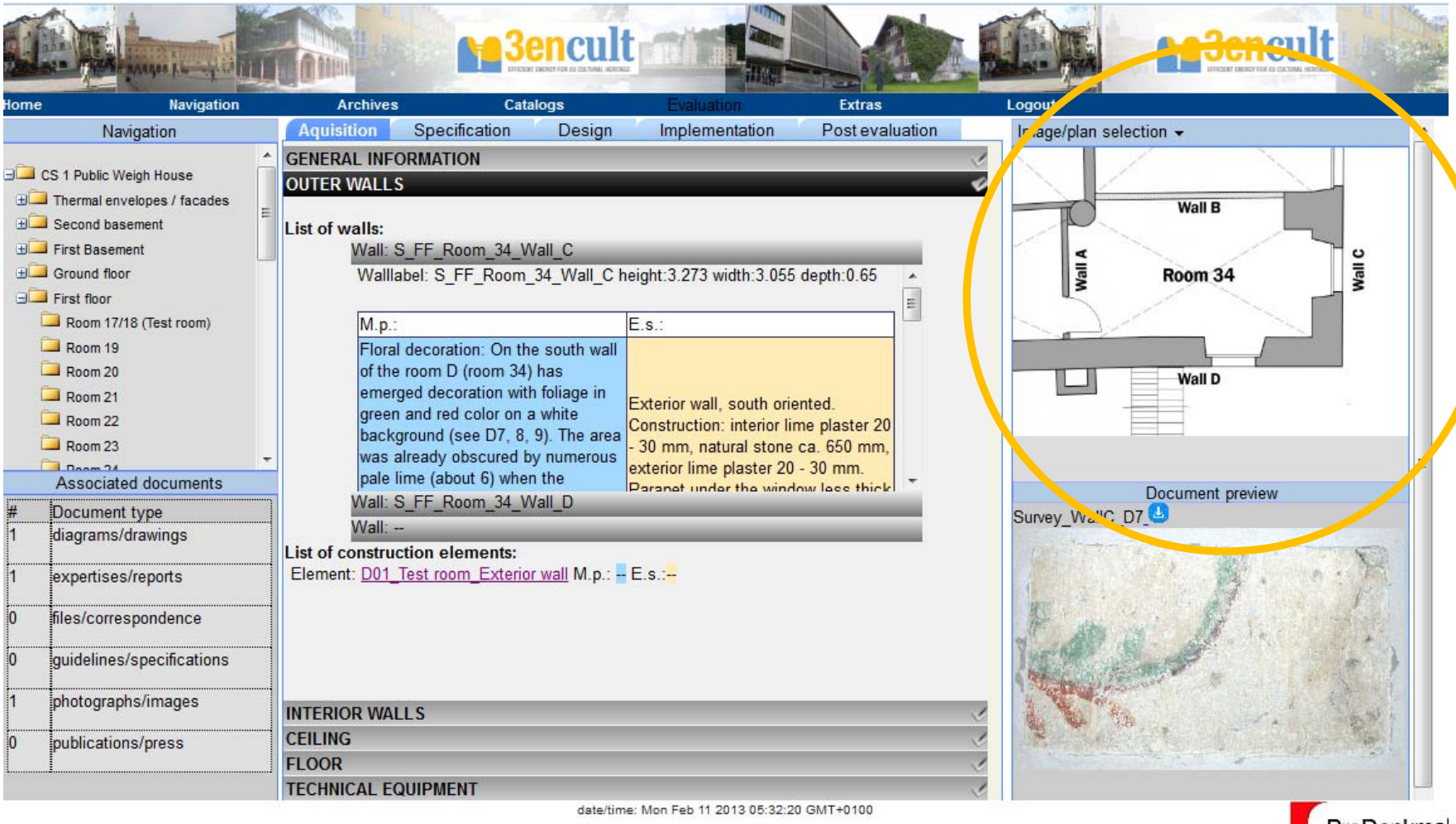
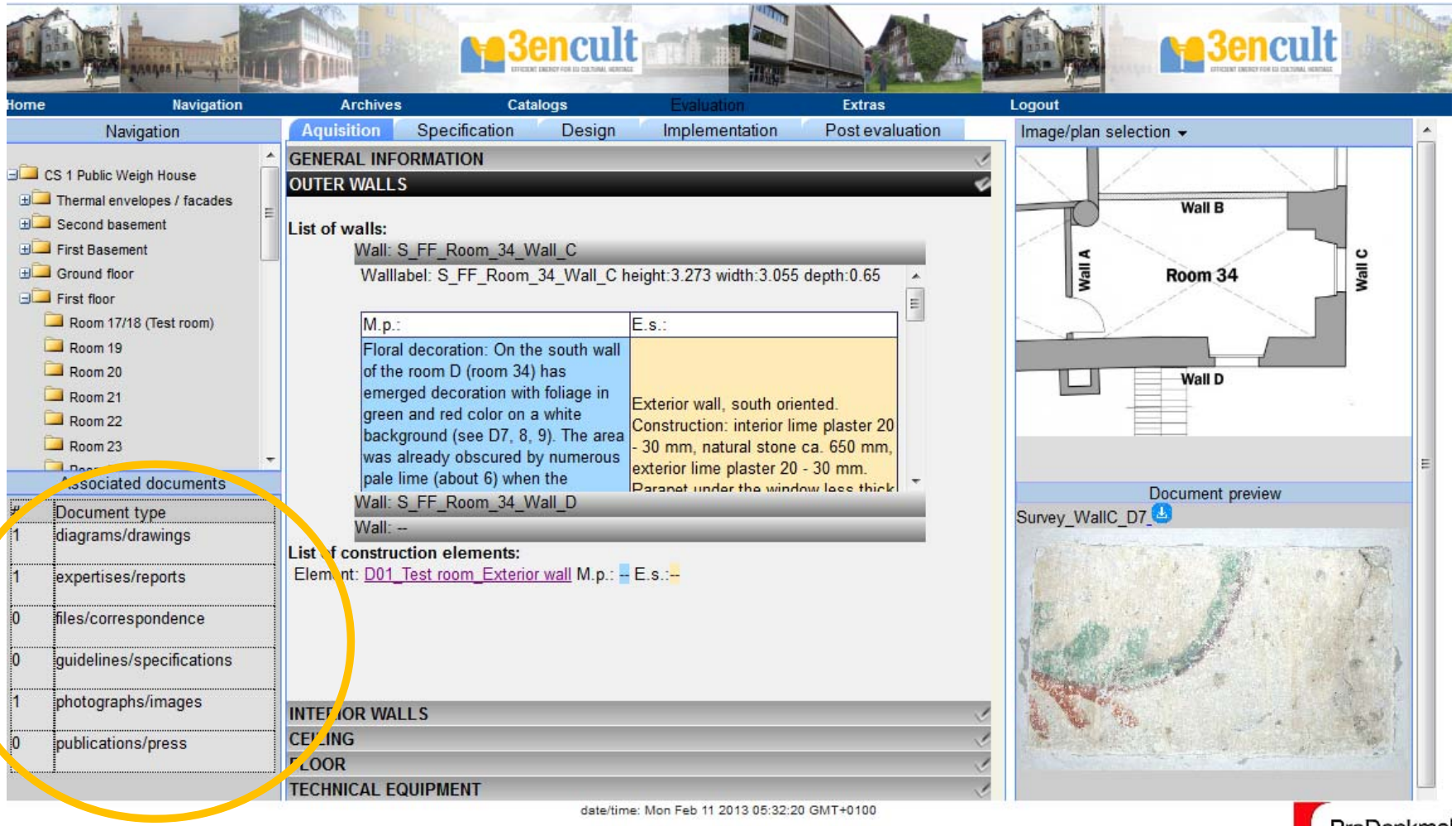
Fotos & maps for orientations



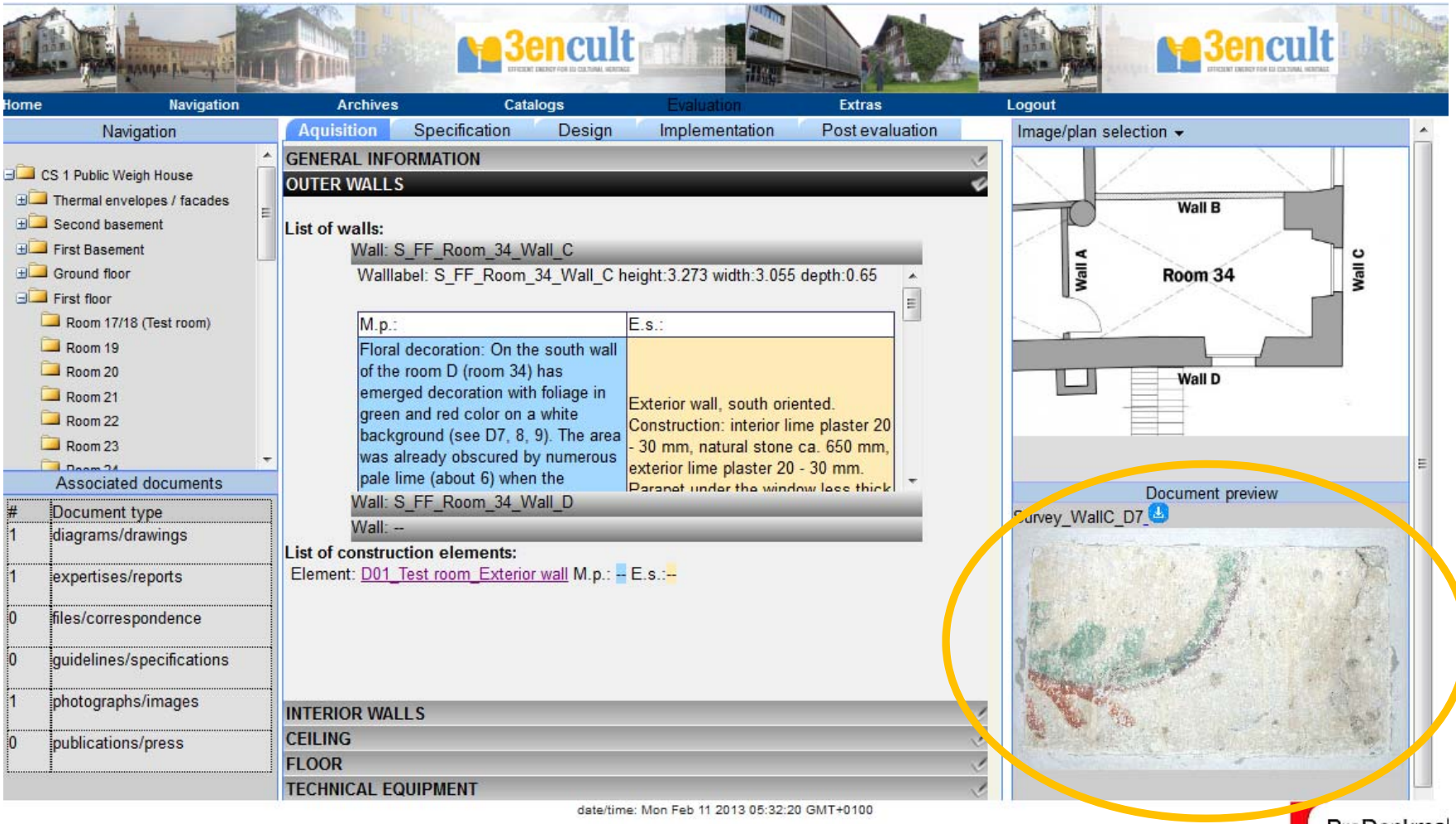
Parallel descriptions in the middle part

ProDenkmal
EURAC research

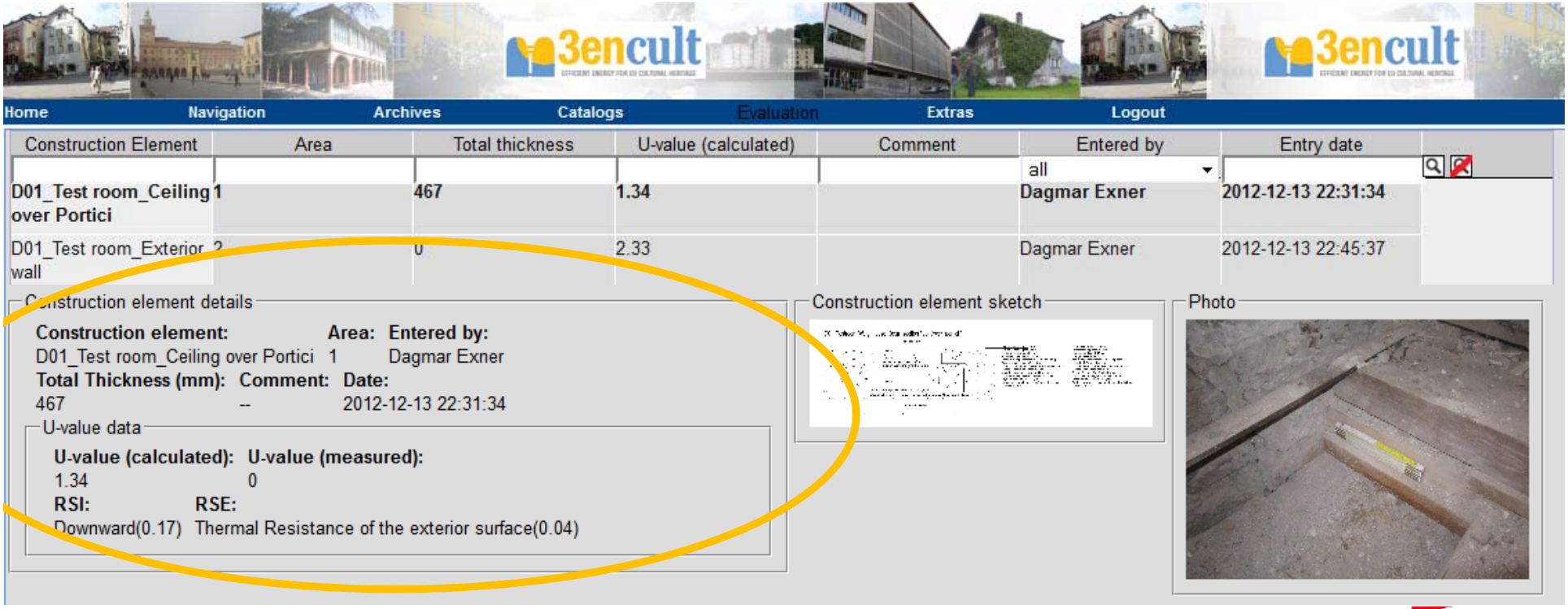
Additional documents



… and their preview



Material and construction catalogues



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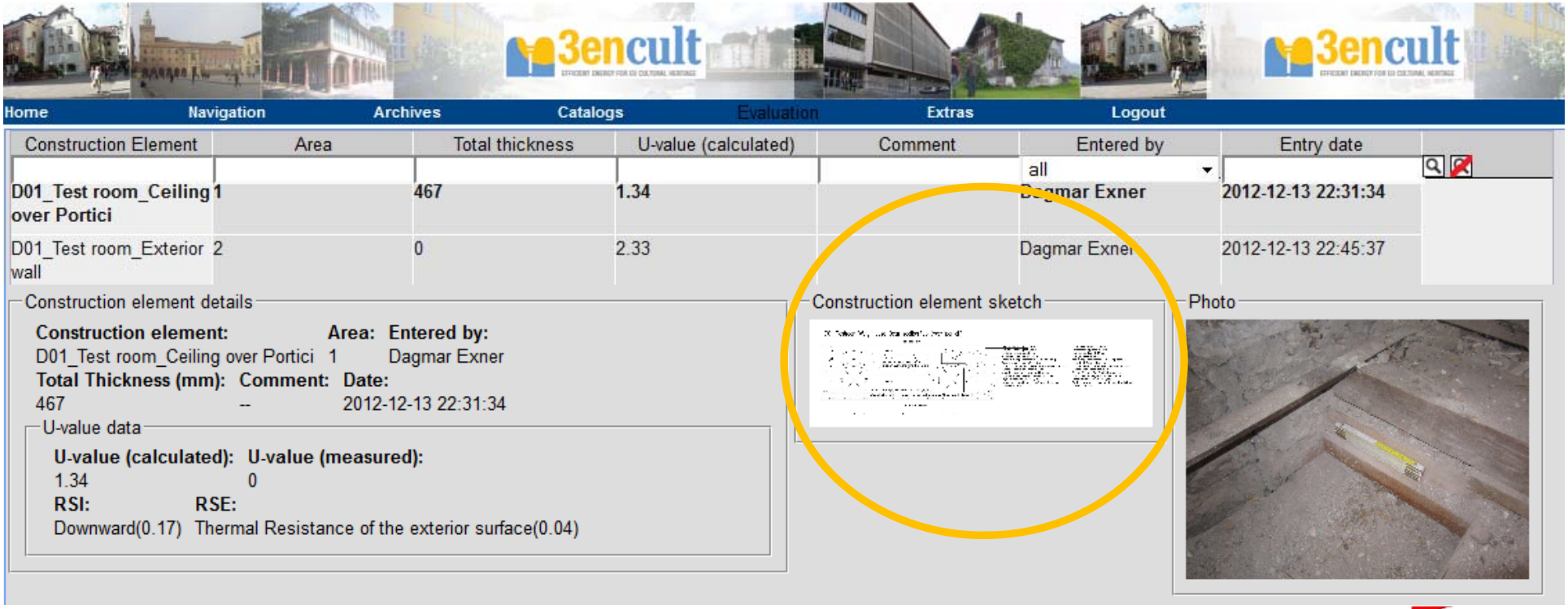
… with detail drawings



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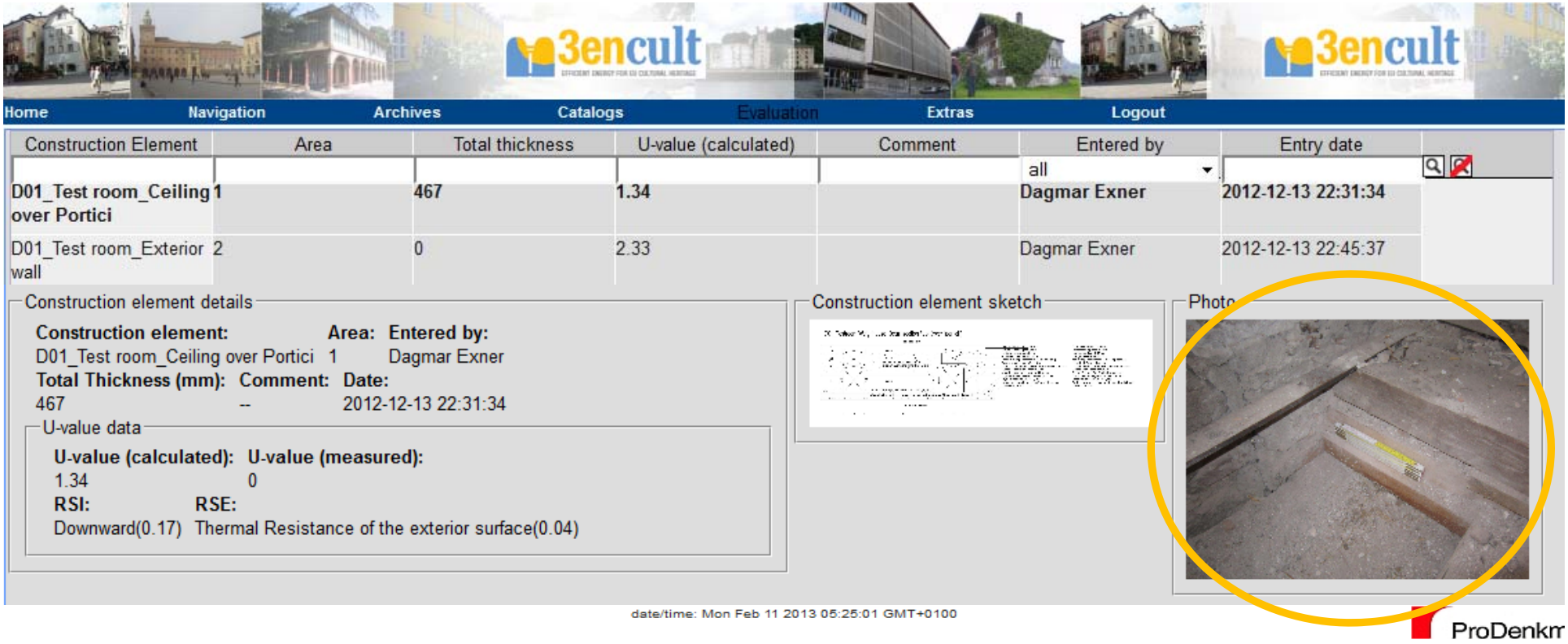
EURAC research

… and picture



ProDenkm

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Standard solution can not exist in historic buildings

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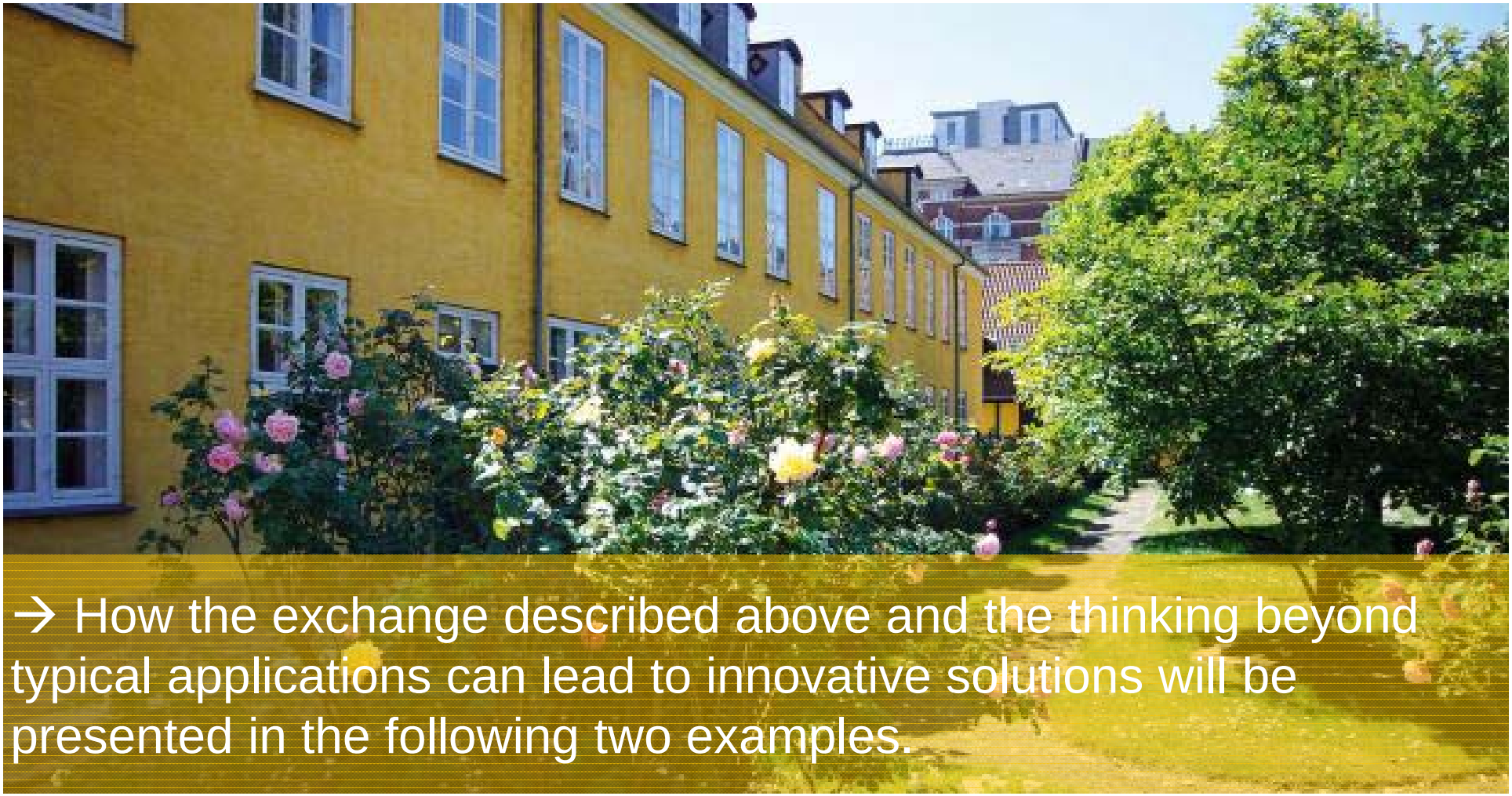

→ How the exchange described above and the thinking beyond typical applications can lead to innovative solutions will be presented in the following two examples.

EURAC research

Public Weigh House Bolzano/Italy

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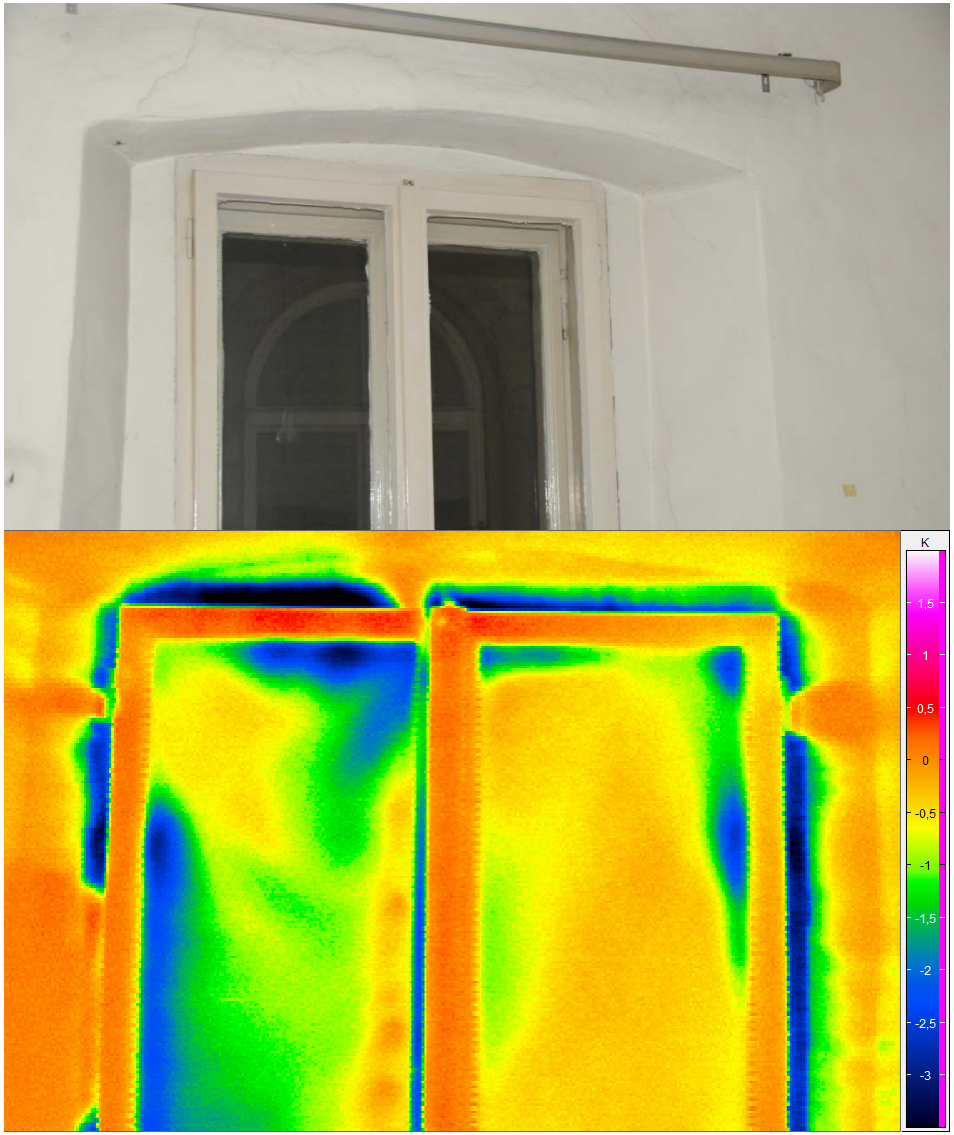
EURAC research

Windows
in the building stock …



… are usually

- not thermally insulating

  e.g. CS1 Waaghaus / Bozen:
  → 33 kWh/m²
  = 11% of total
  transmission losses

- not airtight

  e.g. CS1 Waaghaus / Bozen:
  → ~40 kWh/m²

What to do?

- original windows with heritage value

→ restoration of the existing window

- if original windows have already been replaced – as e.g. in 3ENCULT CS1

→ new energy efficient and aesthetically fitting window

This was a challenge for…

3ENCULT partner
Menuiserie André together
with their development expert
Franz Freundorfer

… in strong collaboration with the consortium!

1st meeting at the Weigh House

With the director of the local heritage office Mrs. Kofler Engl

→ To clarify the specific requirements of the building

→ But also to understand “typical” requirements

- The window size is typical for a baroque window
- Since nearly all windows were exchanged in the middle of the 20th century and there were no information available about the original windows, the heritage office recommends a typical local „baroque“ window:
  - Two sashes, each with two subdivisions
  - Both box-type and coupled window are possible
- Documents and drawings for research

1st meeting & workshop in Bolzano

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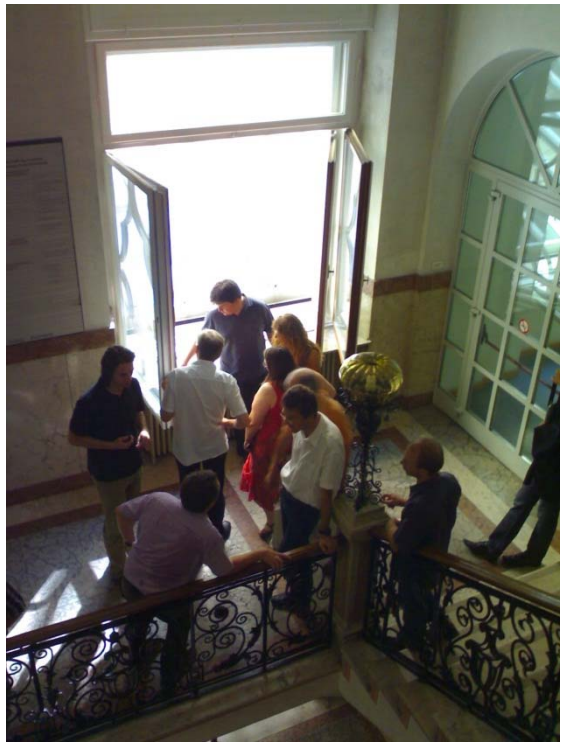

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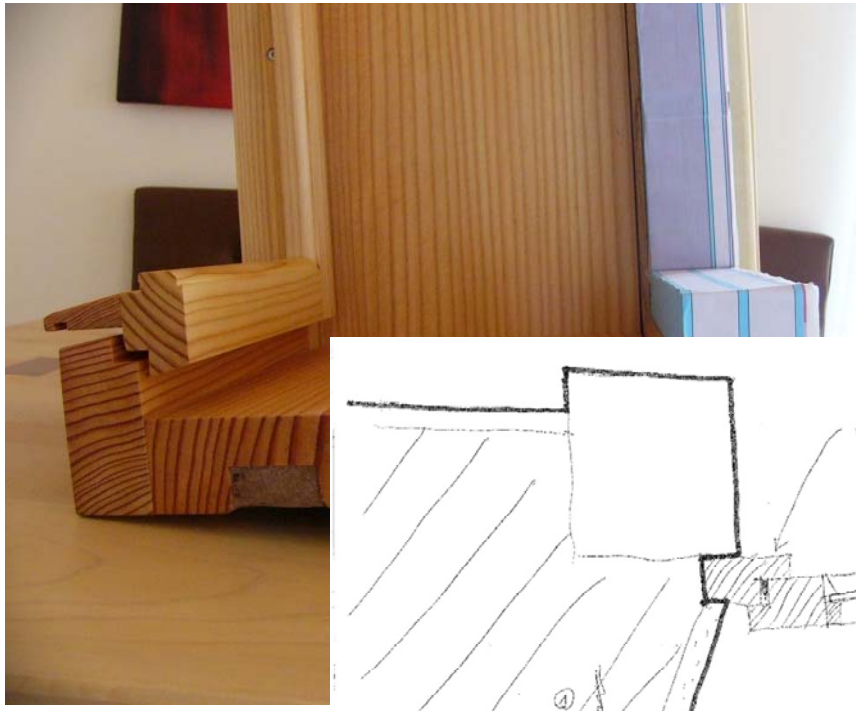
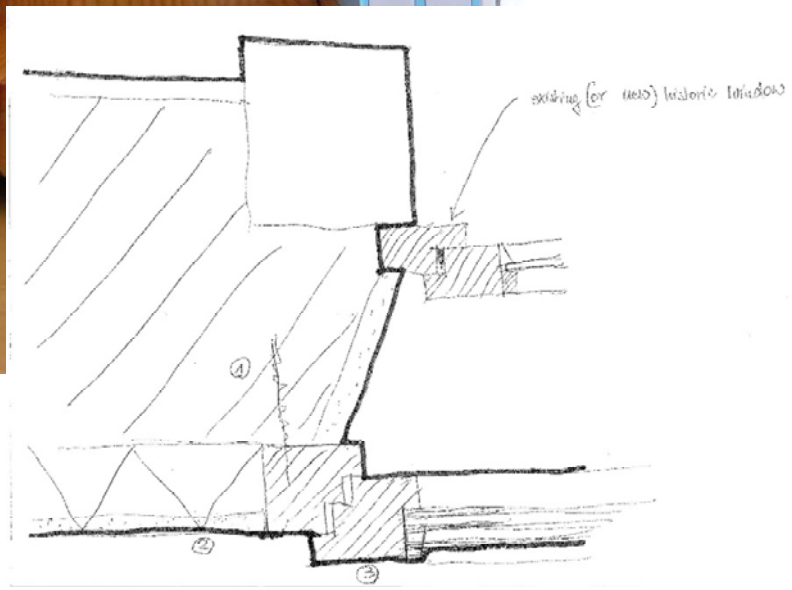
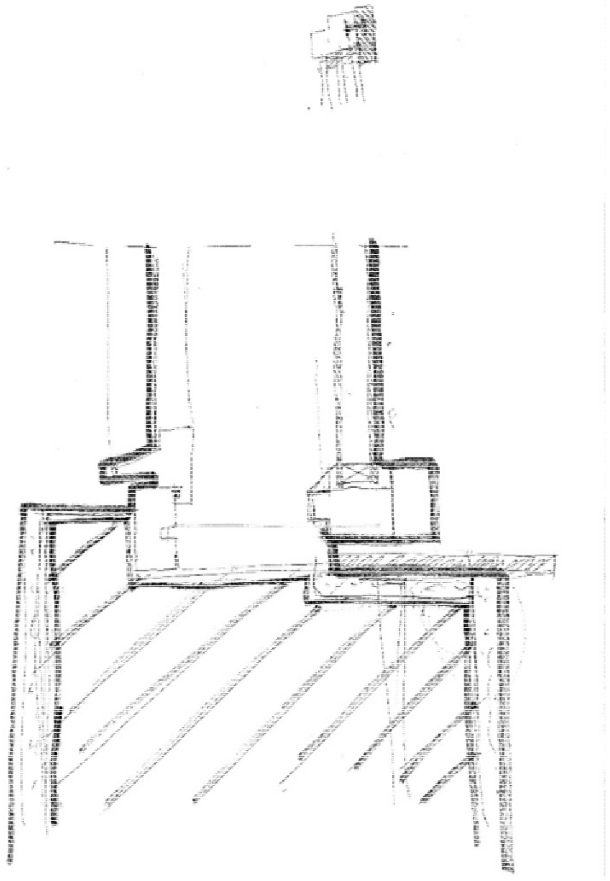
Workshop in Bolzano







EURAC research

1st prototype for CS1, the Weigh House

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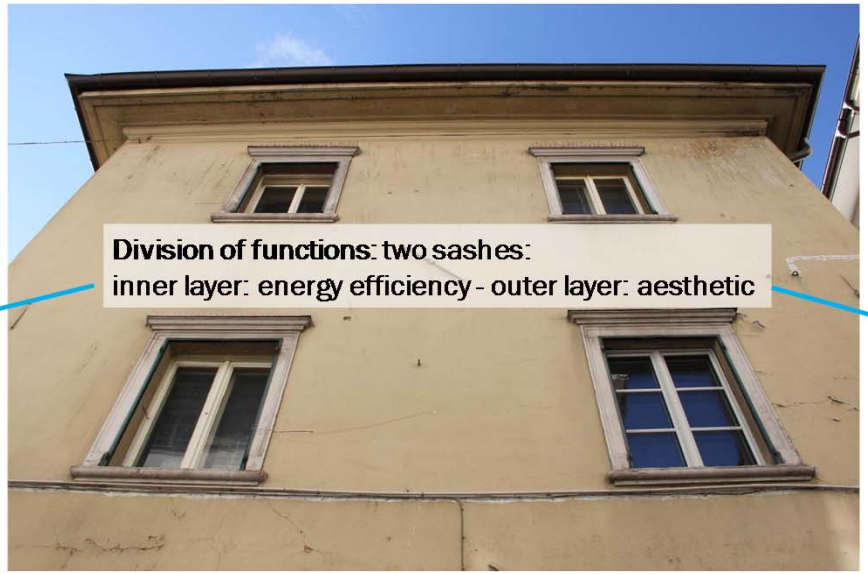
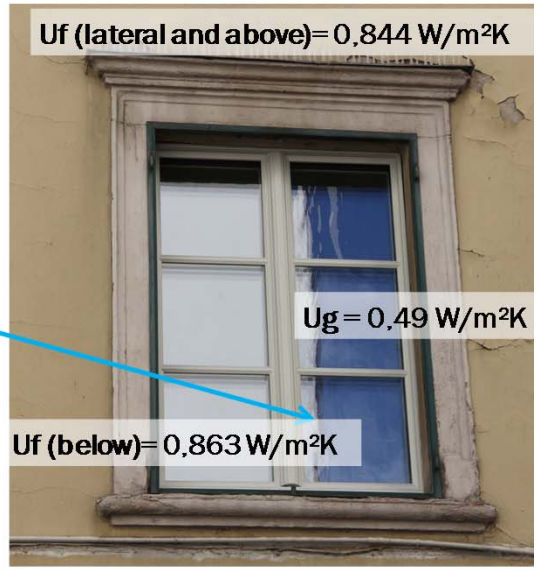
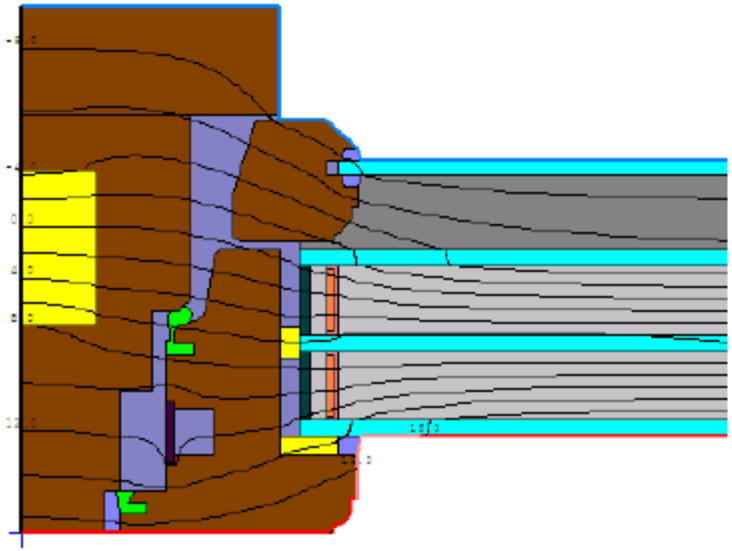




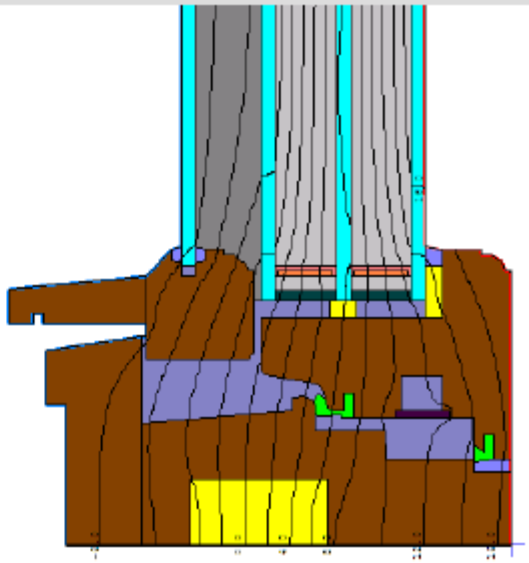
EURAC research

Efficiency of the 1st prototype

Wärmestrom =	8,6102 W
U_f =	0,840 W/(m²K)
Psi_{Spacer} =	0,0206 W/(mK)



Wärmestrom =	8,6504 W
U_f =	0,861 W/(m²K)
Psi_{Spacer} =	0,0203 W/(mK)



U_w=	0,726 W/(m²K)
Psi_{opak} =	0,0985 W/mK

Efficiency of the 1st prototype

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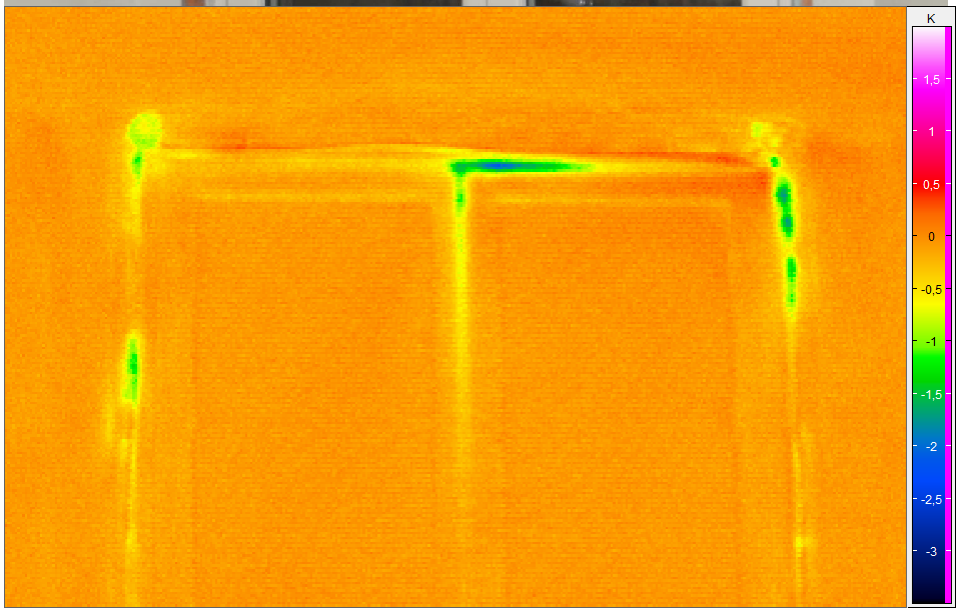

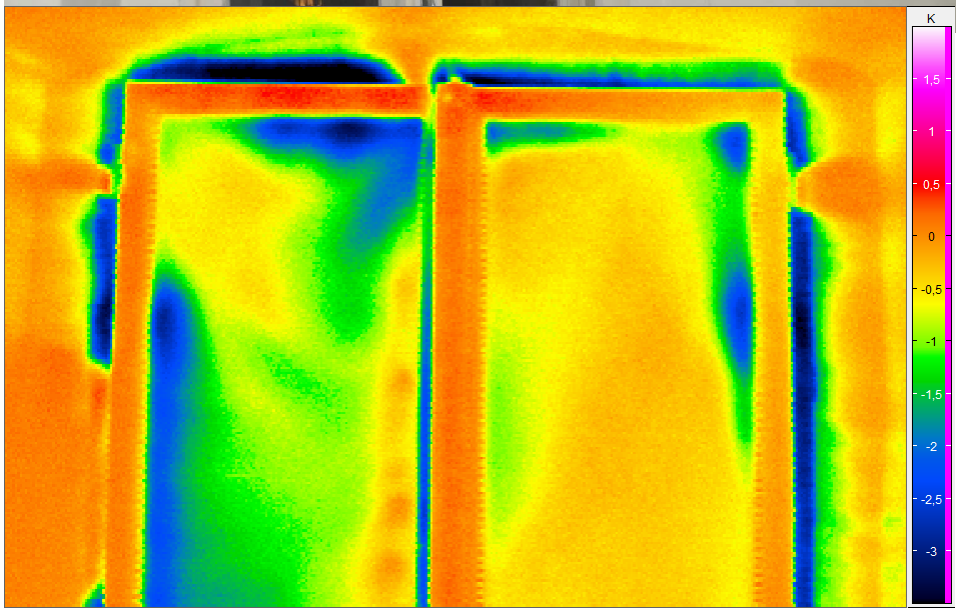

Feedback from conservator

“I do have overall a positive impression as regards frame & sash bar dimension as well as subdivision & proportions.
The optic of the outer glazing seems to me exaggerated, both the too irregular reflection from outside, and distortion from inside. And I ask whether a 3-pane glazing for Bolzano climate is really needed.

Frau Dr. Waltraud Kofler Engl

Further development

Using thin glass→
2mm!

- 2+8+2+8+2
  = 22 mm
- 4+12+4
  = 20 mm

→ Makes the construction even lighter and more delicate

→ Opens new ways for the refurbishment of windows

Résumé André/Freundorfer

- Energy efficiency and historic buildings are a good match!
- Preservation of the historical substance and the aesthetics of protected buildings have first priority
- If exchange → then choose class phA!
- Box-type or coupled window?
  Depends on the regional context and the installation.
- Calculation of the psi-value (thermal bridge) of the installation!
- There is no standard solution
  → but there are design principles for project-based solutions
- Both monument preservation and „passive house“ support the craft

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Active overflow ventilation in the Höttinger school of Innsbruck

EURAC research

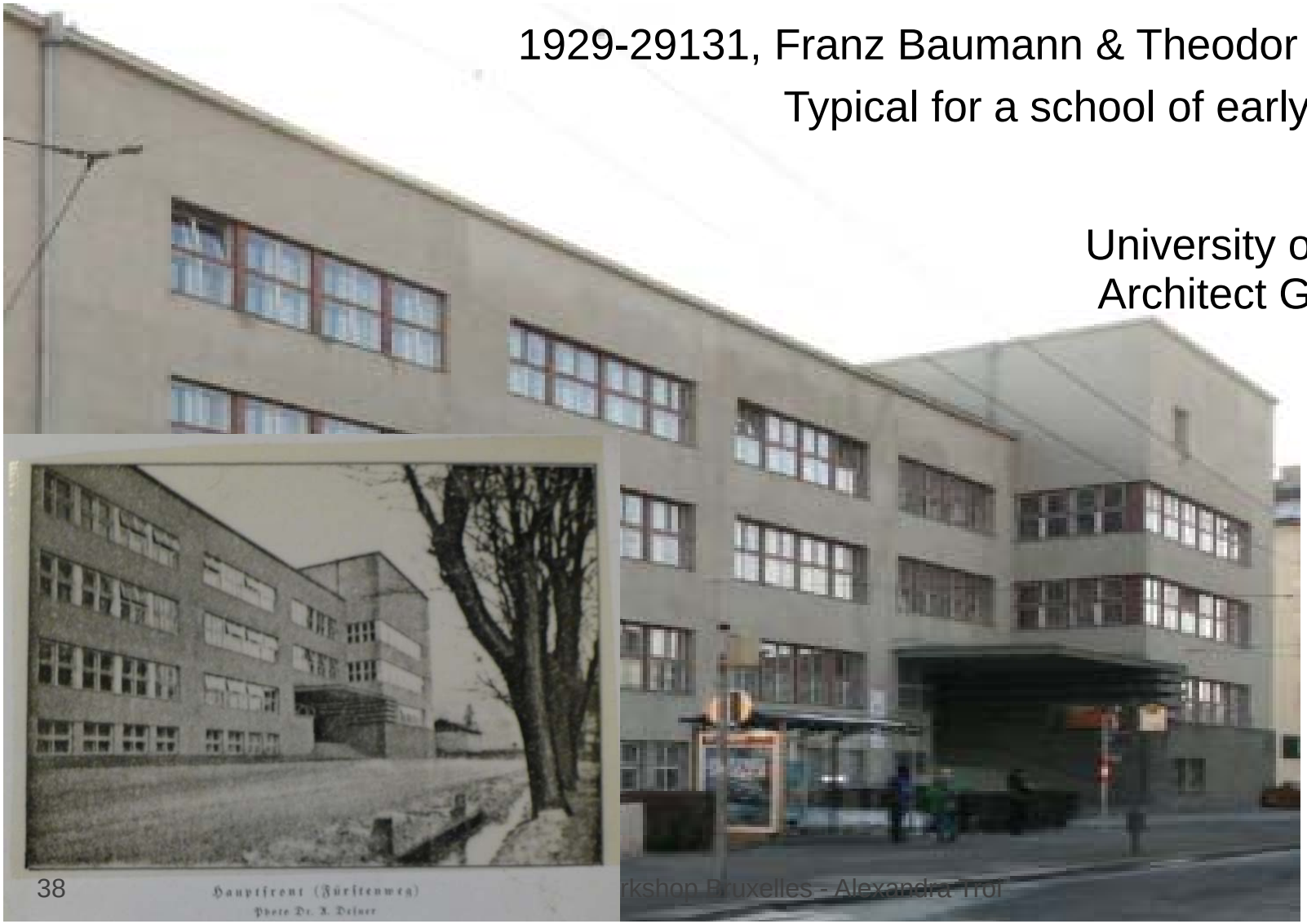
Höttinger School Innsbruck / Austria

1929-29131, Franz Baumann & Theodor Prachensky

Typical for a school of early modernism

In 3ENCULT:

University of Innsbruck, Architect Gerald Gaigg



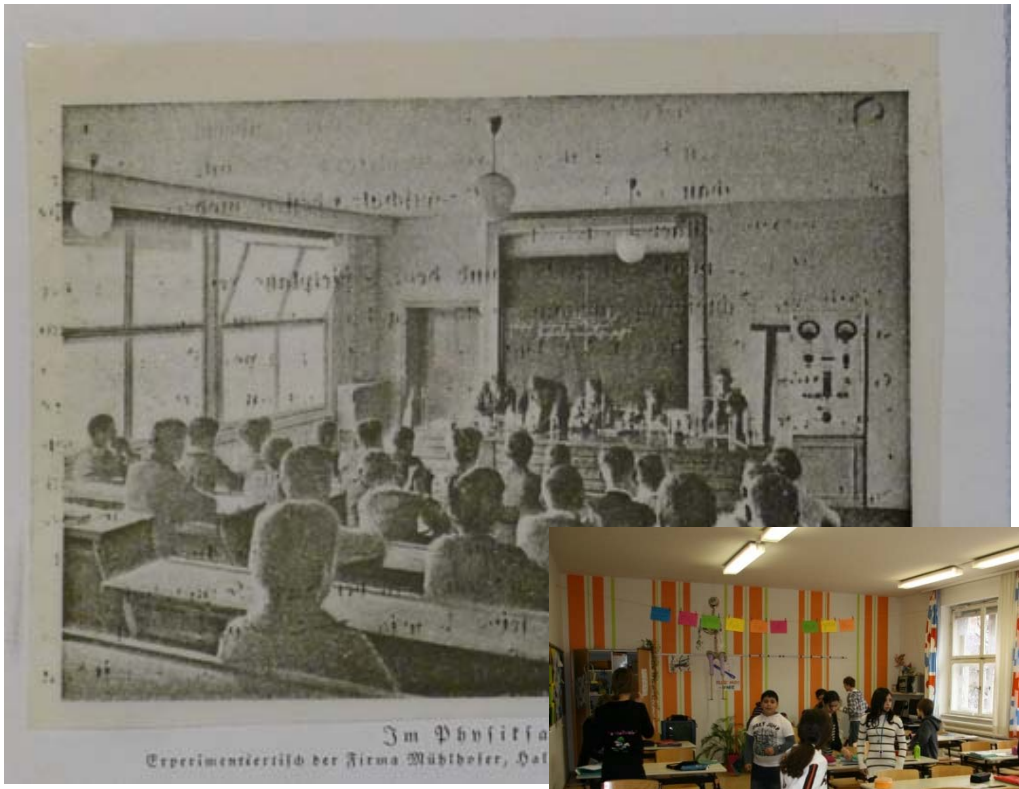
Fresh air demand …

… can not be guaranteed with window ventilation between one lesson and the other

→ Windows are opened also during lessons

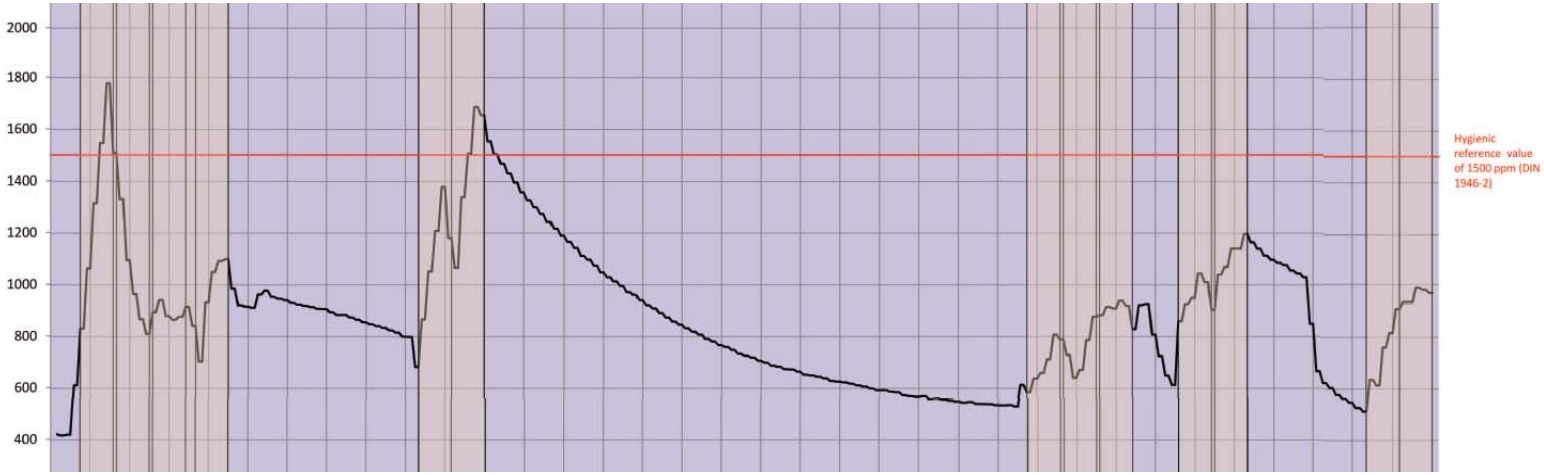
☹ heating demand

☹ comfort

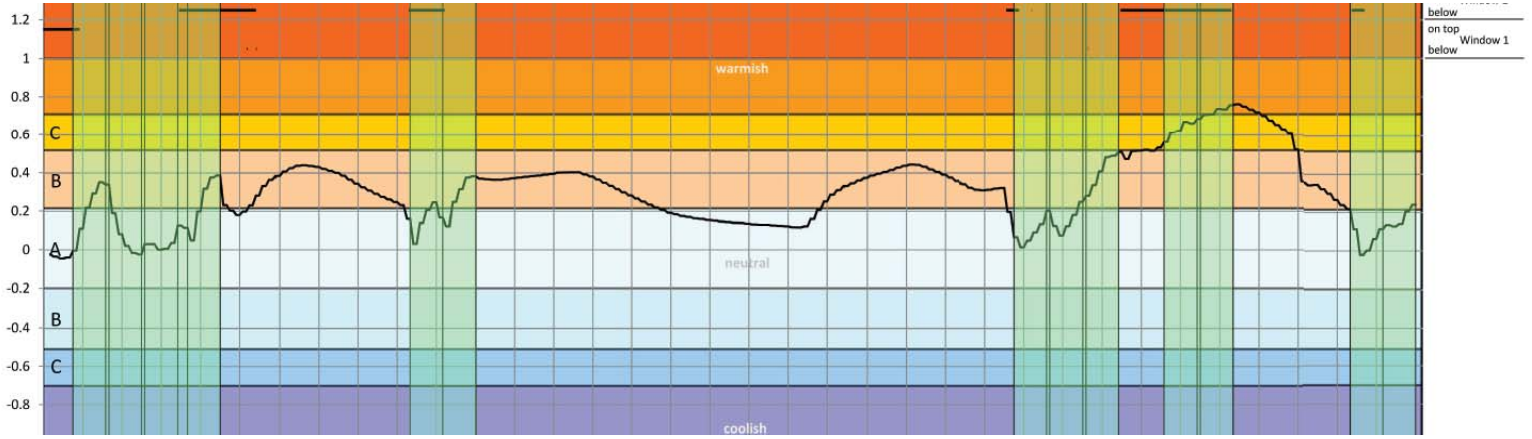


Fresh air demand …

CO_2 (ppm)



PMV



… but which system?

- Central?
  → standard with heat exchanger in cellar
  ☹ horizontal & vertical ducting
  ☹ holes in ceiling
  → vertical ducting
  ☺ no horizontal ducting in the corridor
  ☹ more holes in the ceilings
- Decentralised?
  → one ventilation system per class room
  ☺ less ducts
  ☹ two holes in the facade per room …

What „offers“ the building?

- central staircase
- large corridors
- classrooms that are connected to the corridor

→ Use the potential of the building!

- **fresh air reservoir in the corridors**

Corridors as fresh air reservoirs

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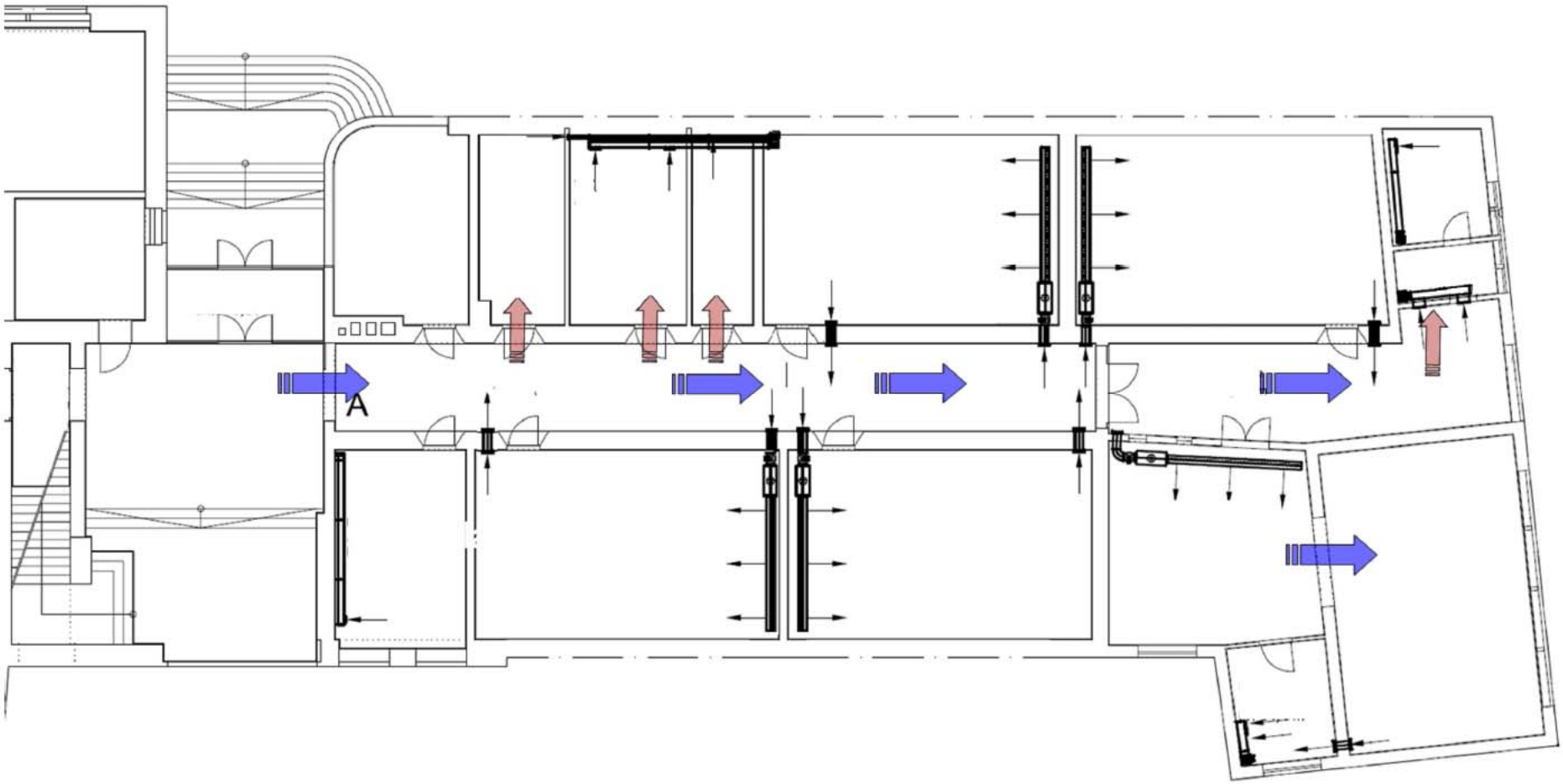

EURAC research

Active overflow

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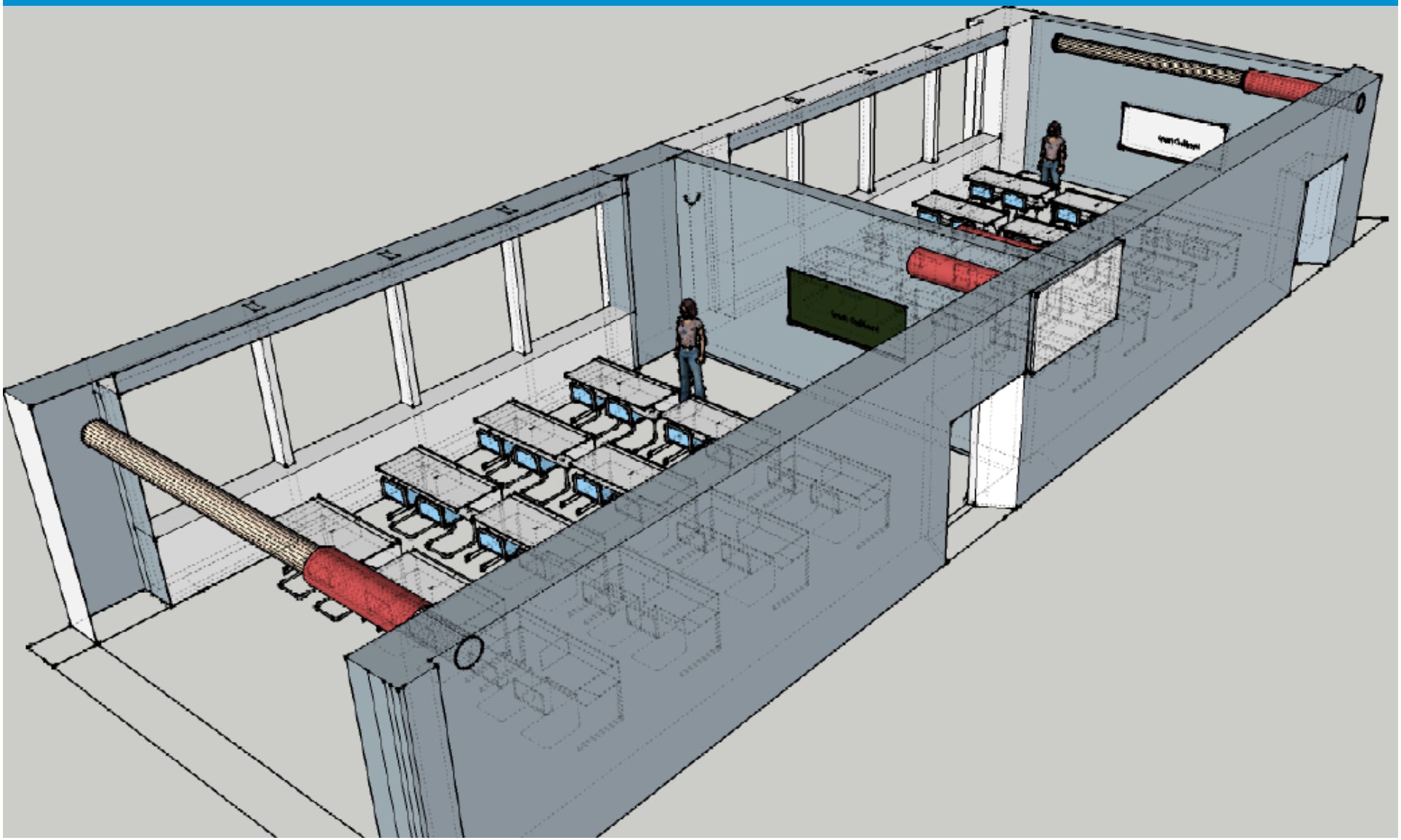

Active overflow

Air supply in the classrooms over textile hoses

Fresh air, exhaust air and heat recovery

- Fresh air reservoir in the corridors
- Active fans for air exchange with the classrooms, even with closed doors → active overflow
- Air supply in the classrooms over textile hoses
- Corridor is supplied over the **staircase** with **fresh air** from the **heat recovery unit** on the roof
- **Exhaust air** over ascending pipes of toilets and wardrooms

Fresh air, exhaust air and heat recovery

- Fresh air reservoir in the corridors
- Active fans for air exchange with the classrooms, even with closed doors → active overflow
- Air supply in the classrooms over textile hoses
- Corridor is supplied over the staircase with fresh air from the heat recovery unit on the roof
- Exhaust air over ascending pipes of toilets and wardrooms

→ Nearly no ceiling openings necessary

→ No suspended ceiling in the corridors

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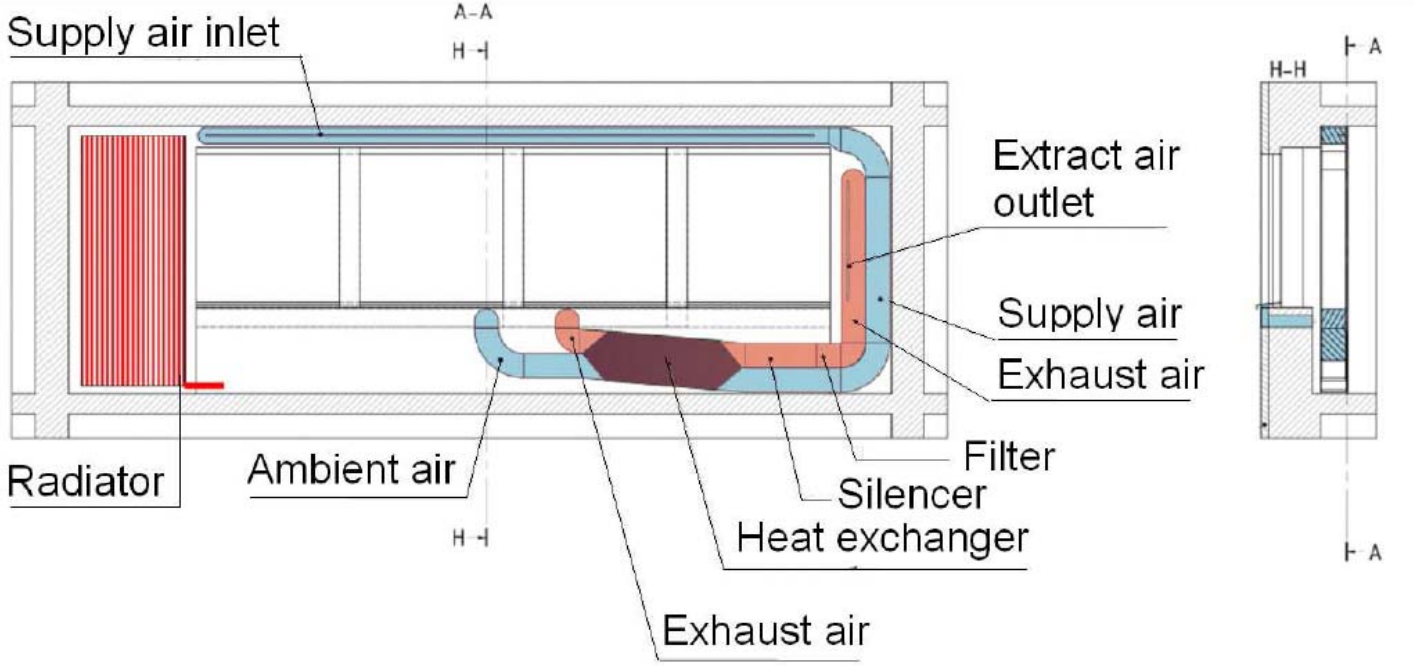
… further solutions

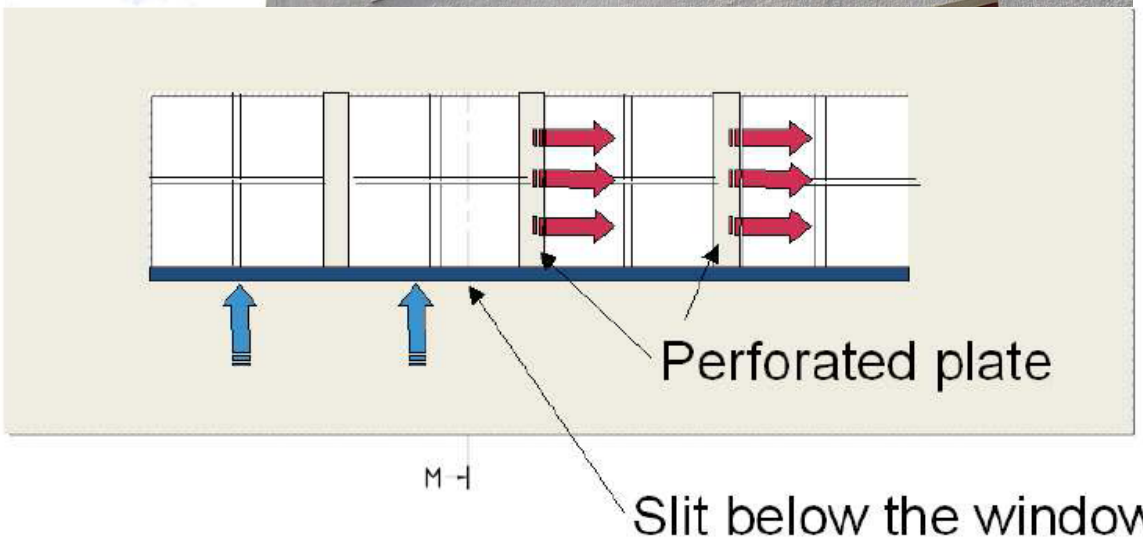
EURAC research

Decentralised ventilation

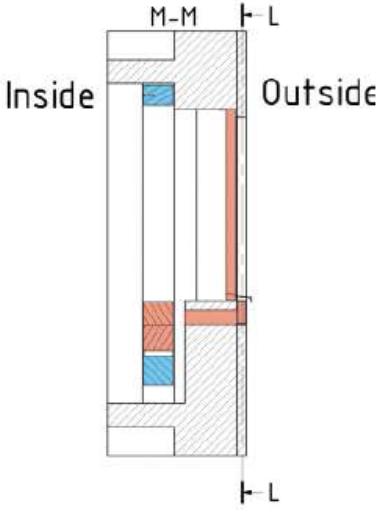
- minimal invasive and nearly invisible mounting of the counter flow heat exchanger in the parapet



Decentralised ventilation



- fresh air through slit below window sill
- exhaust air via perforated plate in front of window post



… in conclusion

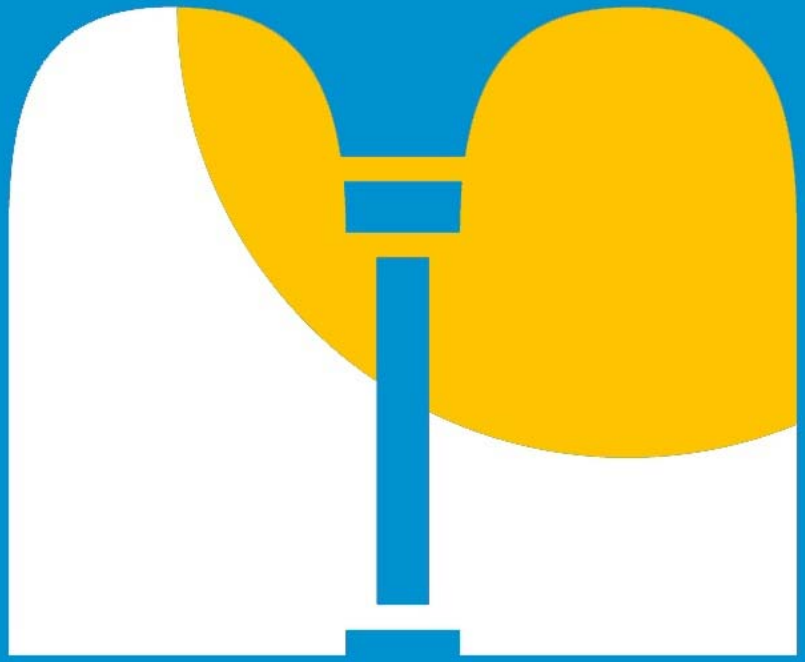
Monument preservation and climate protection are not a contradiction

- both feel committed to sustainability, which includes the preservation of the building as a living space as well as the preservation or our resources.

Good, innovative and heritage compatible solutions can be found

- if the parties exchange,
- if they appreciate and complement each other in their respective expertise
- and consider the building in its entirety
- on the basis of a comprehensive analysis and diagnosis

Tank you for the attention!



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