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Teaching experience with the Historic Building Energy Retrofit Atlas – HiBERatlas

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Abstract. Having tomorrow's architects energized at retrofitting historic buildings might be decisive for bringing towards zero our building stock's carbon emissions while maintaining the values of historic buildings and city centres. To reach this aim, the authors worked with the recently developed Historic Building Energy Retrofit Atlas (www.hiberatlas.com) in an elective course at the faculty of design in Coburg/Germany for architecture and interior design bachelor students as well as students of the master Heritage Design. The HiBERatlas presents best practice examples starting from a description of the building's architecture and heritage values, presenting the overall aim and concept of the retrofit project, only after that explaining the single retrofit solutions and closing with some key figures on the performance. All this supported by photos and drawings which illustrate the single aspects. Since this structure reflects also the good practice in retrofit design, it seemed suitable also for teaching students how to handle the energy retrofit of a historic building: By documenting good case studies, which had been awarded for their ambitious energetic renovation, students gain deep insight into the architectural design and technical implementation. An excursion to the buildings with contact to the architects and building owners was an important part of the course, since the face-to-face meetings with the – often very engaged and enthusiastic – building owners helped understand the reasons behind decisions. The wish of students to however get at the beginning a clear guidance on "what should be done" when retrofitting historic buildings, was addressed in the second editions of the course with a bit more theoretic input in the early classes, but at the same time the clear message, that there are no "one fits all" solutions for the retrofit of historic buildings.

Keywords – HiBERatlas, experimental study format, architecture, best practice retrofit, historic buildings.

1. Introduction

Having tomorrow's architects energized at retrofitting historic buildings might be decisive for bringing towards zero our building stock's carbon emissions while maintaining the values of historic buildings and city centres.

The number of buildings we are talking about is consistent, with an average of 25% of dwellings in Europe built before 1945 and values up to 40% in some countries [1] summing up to 55 million dwellings and presumably 120 million people living in them, if we do not limit ourselves to formally protected buildings but embrace the wider concept of buildings worth preserving because of their cultural value (in line with the scope of EN 16883 [2]). Actually, European climate commissioner and EU executive vice-president Frans Timmermans has recently pointed out "*that one of the greatest challenges the continent faces is converting the historic buildings in Europe's centuries-old cities for a sustainable future*" [3] and when Ursula van der Leyen in her state of the union address launched the idea of a New European Bauhaus [4] she clearly pointed out the need for architects, artists, students, engineers and designers to take over their role and make the renovation wave happen. Europa Nostra and the Architects Council of Europe endorsed the initiative and underlined at the same time the importance of "*cultural heritage as an integral dimension of the New European Bauhaus initiative*" [5] and building on the 2018 Davos Declaration Towards a high-quality Baukultur [6][7].

How to engage owners and architects in finding the appropriate solutions in order to reduce the climate impact of historic buildings and preserve their characteristics and values? Learning from best practice which is documented with the necessary level of detail can be successful strategy, as Femenìas has shown [8], especially if it articulates the heritage value (as Lidelöw [9] states) and explains why the specific solution is compatible with conservation in the specific case [10]. Herrera et al [10] also point out that the observed moving away from a sharp distinction between heritage and not-heritage buildings does also ask for a certain negotiation when it comes to what kind of energy retrofits can be considered appropriate and that "this means that conservation aspects should be taken into account when choosing the energy retrofit measures, even when the building is not formally listed, but also that no measure should be ruled out beforehand, regardless of the level of protection". That visual presentation of the best practice supports taking it up especially for the target group of architects and owners is a second postulate of Herrera et al. [10]

From the above we can deduce that architects will have a decisive role if we want the renovation wave - first of all - to be implemented and do this in a way compatible with keeping the values and diversity of our historic built environment. The education of future architects is thus of major importance and the authors present here a course format tested at the faculty of design in Coburg/Germany for architecture and interior design bachelor students as well as students of the master Heritage Design, which is based on the recently developed Historic Building Energy Retrofit Atlas (www.hiberatlas.com) [11] with the aim to engage the students at retrofitting historic buildings by learning from best practice during the course.

2. The HiBERatlas

The HiBERatlas [11] presents best practice examples in a very visual and "fun to read" way – starting from a description of the building's architecture and heritage values, presenting the overall aim and concept of the retrofit project, only after that explaining the single retrofit solutions and closing with some key figures on the performance. Descriptions are supported by photos and drawings, which illustrate the single aspects.

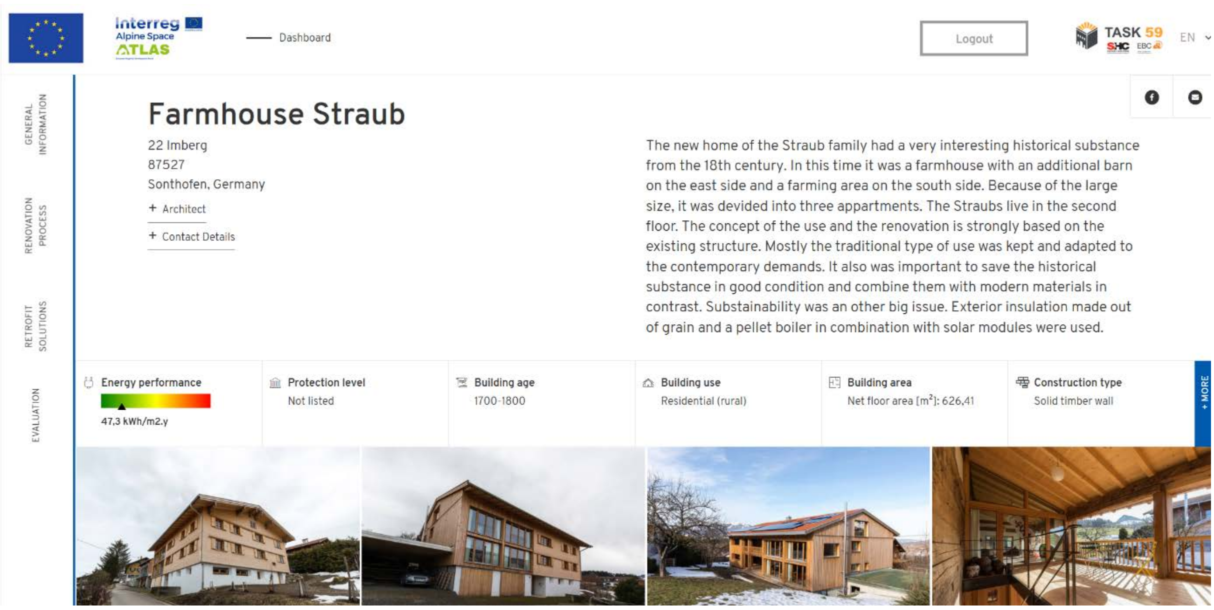

Figure 1. HiBERatlas, at the left the links which allow for easy navigation to the single section – from General information over the Renovation process, the Retrofit solutions to the Evaluation

3. The format of the study course

The course format is based on the idea that by documenting good case studies, analysing available documents and complementing them where needed, talking to architects and interviewing the building owners, students gain insight into both the architectural design and technical implementation, learn how and why decisions have been taken and at the same time contribute to the case study documentation with calculations and data analysis where needed.

It has been developed as elective course with 2 SWS (contact hours per week per semester) and 3 ECTS for students from architecture and related studies with lectures, excursion and seminars with crits as described in detail in the following subsections.

3.1. Introduction to the topic of energy retrofit of historic buildings

The course starts with an introduction to the topic of energy retrofit in historic buildings by

- setting the scene and introducing climate change and our need to answer to it as driver
- defining the scope, by introducing the wider definition of buildings with characteristics “worthy to be preserved” and exemplifying it with examples relevant for their experience → *with images*
- underpinning the importance, by presenting numbers, not only on European level as here in this paper or in [Dubrovnik] but broken down to the country/region of the students → *letting students estimate numbers e.g. via a mentimeter survey* and → *presenting data with some catchy charts*
- showing the potential of reducing the energy demand while respecting historic values → *with just some examples, or the overview shown in Figure 2*
- and closing possibly with the statement of an owner, describing the needs and expectations but also their will to preserve → *with a video*.

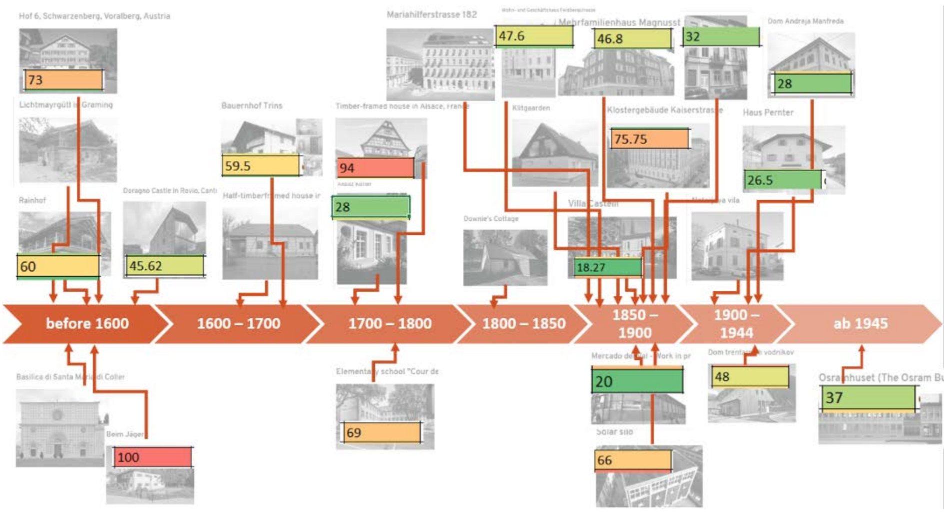

Figure 2. Also historic buildings have the potential to reduce the energy demand to low values – preliminary assessment of the first 25 good practice cases in the HiBERatlas (status 11/2019)

Figure 3. Testimonial videos from Bauern(h)auszeichnung award available on [12].

In both editions of the course in winter term 2019/20 as well as winter term 2020/21 we worked to this aim with videos from the Bauern(h)auszeichung award [Bauern(h)auszeichung] in South Tyrol, where owners of the old farm houses describe how they lived in buildings without domestic hot water and only two rooms heated, but at the same time describe that they want to keep what their ancestors built, adding “their piece” in a sustainable way.

3.2. Working with the HiBERatlas as tool

Since this structure of the HiBERatlas also reflects the good practice in retrofit design and the approach described in EN 16883 [2], students are introduced to how to handle the energy retrofit of a historic building directly presenting the HiBERatlas and its parts: (i) Start from understanding the building - its values as well as its weaknesses and potentials, (ii) define the aim and only then (iii) develop the retrofit solutions which are (iv) technically compatible and respect the heritage value and (iv) assess them in a holistic way – with regard to energy performance, but also economics, life cycle, other sustainability aspects and last but not least comfort reached. The importance of a post-occupancy evaluation in practice is underpinned with asking for monitored data (and being them collected bills only) in the HiBERatlas. A checklist guiding through the process and listing the information which is needed is available, a video on how to introduce best practice in the HiBERatlas is in elaboration and will be available with the end of ATLAS project (early summer 2021). Students are provided with documentation in terms of drawings, photos (ideally both before and after retrofit as well as building site), descriptions (often available because requested for building permit, but also existing publications etc.), energy performance calculations (usually available, even if not always as e.g. if a listed building does not have to formally meet any minimum performance.

3.3. Excursion to the buildingsl

An excursion to the good practice buildings with contact to the architects and building owners is an important part of the course: it gives students the possibility to see the building, make photos, ask questions to the owner and the architect and complete the documentation, with objective information but also the personalised views which can make the HiBERatlas interesting and “fun to read”. Usually, such excursions will be organized in smaller groups.

3.4. Extra appointments for “knowledge pieces”

To make up for different background knowledge of students in an elective course (in Coburg e.g. bachelor and master students from 3rd year onwards, architecture and heritage or interior design, see section 4), it was necessary to introduce some topics in voluntary extra appointments which covered

- Comfort and Use
- (Interior) Insulation
- Windows & Ventilation
- Energy Balance
- Life Cycle & Embodied Carbon

Often it is possible to start from students’ personal experience, e.g. when talking about comfort and use, and collected qualitative information is then completed with the introduction of quantitative methods. For interior insulation both thermal aspects and humidity are considered, looking at vapour tight and capillary active approaches, and – from a methodological point of view – e.g. introducing the physical concept in a whiteboard dialogue, presenting two examples and keep it hands-on with a calculation tool (in the specific case ubakus.de was used). The typical performance of historic windows and related retrofit options is introduced and discussed together with the influence of airtightness on interior humidity and the importance of ventilation – be it natural or mechanical. Energy balancing can be introduced with an example building (in the specific case “Ansitz Kofler” was used), but also looking together at energy performance documentation files (what can be read out where in the file). Finally, introducing life cycle concept and data sources (e.g. does the above mentioned ubakus.de also offer life cycle evaluation) can be made hands-on with small group work comparing two materials.

3.5. Documentation of building values and the overall concept

To emphasize the importance of understanding the building, its architecture and values, before thinking about specific retrofit solutions, the students, in a first phase, only fill in the section of the HiBERatlas about (i) the architecture and its urban context, (ii) the heritage significance in terms of how it was assessed as well as elements to be preserved, (iii) the state of repair in terms of conditions of the envelope before retrofit and a description of the pre-intervention building services and (iv) the aim of the owner for the retrofit. The documentation is presented in the first review meeting to the whole group, working directly with the preview of the HiBERatlas.

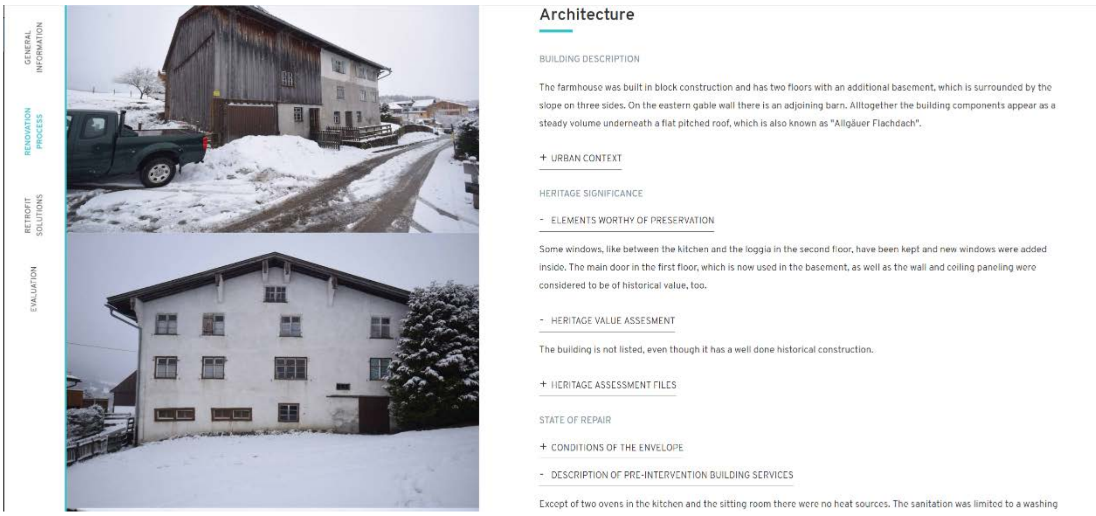

Figure 4. HiBERatlas, second section presenting the architecture and it values.

3.6. Documentation of the chosen retrofit solutions

In a second phase, the chosen retrofit solutions are documented. The HiBERatlas guides through this process, by grouping different intervention areas

- External walls (number of walls is defined by the user depending on the needs of the case)
- Windows (number of windows is defined by the user depending on the needs of the case)
- Other interventions (including roof, floor, measures to increase air tightness and "other")
- HVAC (including heating, ventilation and domestic hot water)
- Renewable energy systems (proposing different sources from solar thermal and PV over biomass to wind and geothermal)

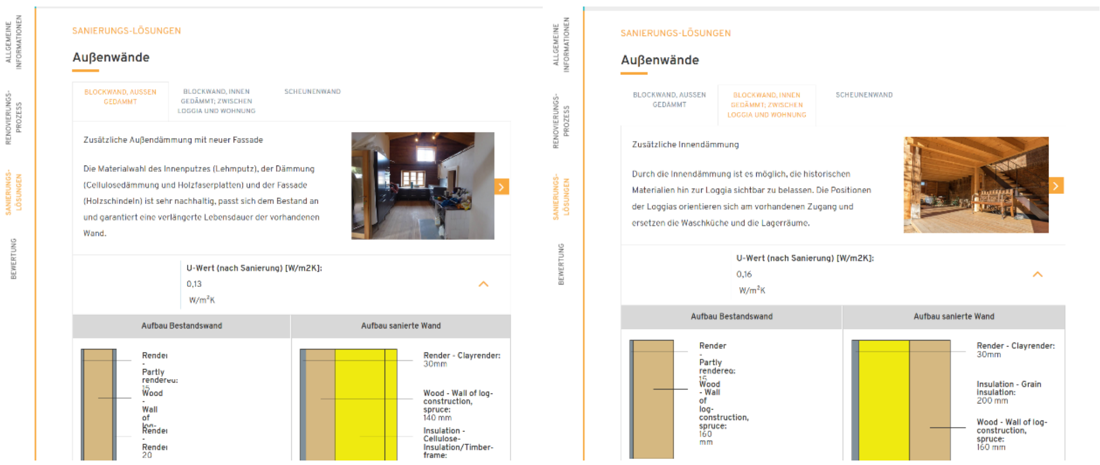

Figure 5. HiBERatlas, third section presenting the specific retrofit solutions.

For each solution, a field for a general description of the intervention is available, and one to specifically describe why the solutions were considered compatible with conservation issues in the specific case. Furthermore, the HiBERatlas asks for photos and drawings and more specific technical information which depends on the solution type: for walls e.g. the stratigraphy before/after retrofit is requested and the respective U-values, for heating the energy source and the type of system are asked .

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In this phase also more details can be inserted in the renovation process section, e.g. the lessons learned and the tools used. Finally, the evaluation section is filled, with information on energy demand before and after retrofit, but also achieved comfort and costs, if available on life cycle basis.

Figure 6. HiBERatlas, fourth section with some key numbers for evaluation

Also, this part of the documentation is presented browsing through the HiBERatlas. This gives the possibility to the whole group to ask questions and to the teacher to provide feedback and crits if needed and indicate points which need more clarification.

3.7. Feedback from HiBERatlas reviewers

As foreseen by the HiBERatlas, good practice documentations go through a peer review process before being published: two experts form the international projects developing the HiBERatlas (IEA SHC Task59 and Interreg AS ATLAS), one with technical background and the other with conservation background review them, with the aim to ensure robustness and improve if needed the way the buildings are presented [10]. The review template includes thus both a traffic light system with overall evaluation and specific feedback on technical and conservation compatibility, completeness of information. While the general qualification of the good practice case for the HiBERatlas should be ensured before the students document it – they should learn based on actual good practice – the feedback on what and how information is presented can be considered a valuable external feedback on their ability to present what they have understood. To include the review process in the course format means however to foresee enough time for the experts to review and the students to include the feedback in a revision of their work.

3.8. Final presentation

The final presentation is again based on browsing through the HiBERatlas, presenting the building, its values, the retrofit concept, the chosen retrofit solutions, what was achieved, and which lessons were learned. The audience can be enlarged to fellow students and colleagues, but also outside academia, inviting the architects of the presented buildings to participate and invite also other colleagues.

4. The Teaching experiences

The above concept of "teaching by consideration of examples" has up to now been implemented twice at Coburg University of Applied Sciences: in winter term 2019/20 and 2020/21. In both years the students came from all three potential programs, two of them bachelors, one master: Interior Design B.A., Architecture B.A. and Design M.A.. The second year the students where slightly younger (or rather earlier in their curriculum) with an average term" of 6.9 compared to 7.5 (considering 1st term master as term 9 and 3rd term master as term 11), this being mainly due to a total of 4 architecture student from 5th term joining as well as 2 design students from 1st term, and no interior design from 7th term. Leaving the possibility on how to build groups of 2 or 3 open, resulted in 3 out 6 groups being mixed in 2019/20, but only 2 out of 8 in 2020/21.

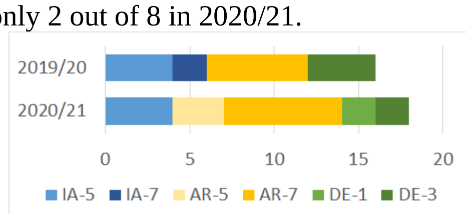

Figure 7. Students distribution: AI – Bachelor Interior Design, AR – Bachelor Architecture, DE - Master Design, number in legend corresponding to term

When asked about their motivation to participate in the elective course, besides pointing out that retrofitting buildings will be the task of tomorrow rather than building new, several students actually mentioned that they find working on the existing, where each situation is different and you have to understand it before developing the right solution, is what encourages them far more than the always same new building.

In the first year the balancing of different background – especially from the 5th term interior design students – was mastered with “side explanations” after the lectures/meetings hold in presence. Since this (a) in the pandemic situation 2020/21 would not have been possible and (b) the feedback from first year’s students was anyway that they would have appreciated a bit more background knowledge, the extra appointments – as described in section 3.4 - have been introduced in 2020/21. They were actually used by the majority of students.

The buildings documented were in 2019/20 chosen from farm houses which had received an award for exemplary conservation compatible energy retrofit – the Bauern(h)auszeichnung [12] which has been awarded to two buildings each year since 2014. In 2020/21 this approach would have been continued, if it would not have been clear that with the pandemic situation an excursion from Coburg (in Germany) to South Tyrol (in Italy) would not have been possible. In order to give students a chance to visit their buildings, we therefore prepared a list of good practice buildings in Bavaria, looking again at buildings which had been awarded e.g. by the KfW for exemplary interventions. Table 1 lists the documented good practice cases with some key information: When selecting the buildings, we ensured to have both listed and not listed buildings. In the 2nd year, when the focus anyway was shifted from farmhouses, also to have a range of different uses.

Table 1. Good practice cases documented in 2019/20 and 2020/21.

Name	Age	Use	Listed	Energy demand after retrofit
Mairhof, Partschins (IT)	1600-1700	Farm house, agritourism	yes	66 kWh/m²a
Ruckenzaunerhof, Latsch (IT)	before 1600	Farm house	yes	110 kWh/m²a
Außergrubhof, Ulten (IT)	before 1600	Farm house, agritourism	no	107 kWh/m²a
Obergasserhof, Vintl (IT)	before 1600	Farm house	yes	99 kWh/m²a
Oberbergerhof, Montan (IT)	before 1600	Farm house	yes	135 kWh/m²a
Platzbon, St. Andrä (IT)	before 1600	Farm house, agritourism	no	74 kWh/m²a
Ackerbürgerhäuschen	before 1600	Town house, residential	yes	62 kWh/m²a
Townhall Bergrheinfeld	1600-1700	Town hall, office	yes	55 kWh/m²a
Townhall Burgkunstadt	before 1600	Town hall, office	yes	52 kWh/m²a
Badhaus Volkach	before 1600	Town house, residential	yes	n.a.
Haus Moroder (IT)	1900-1944	Town house, residential	no	45 kWh/m²a
Ritterhof, Waltenhofen	1850-1899	Rural, residential/office	no	
Bauernhaus Straub, Sonthofen (DE)	1700-1800	Rural, residential	no	47 kWh/m²a
Sep Ruf, Dorfen (DE)	1900-1944	Rural, residential	yes	125 kWh/m²a

The feedback of the students – both directly and in the anonymous standard evaluation forms – was very positive. Most appreciated was the excursion and the face-to-face meetings with the – often very engaged and enthusiastic – building owners. Interesting to note was the wish to however get at the beginning a clear guidance on “what should be done” when retrofitting historic buildings. This was addressed in 2nd edition of the course with a bit more theoretic input in the early classes. At the same time the comparison of the cases at the end gives hints and ideas, where to practically start from, but also the clear message, that there are no “one fits all” solutions for the retrofit of historic buildings.

5. Conclusions

Students are very open to the topic of energy retrofit in historic buildings, as the query on their motivation to participate in the elective course has shown. Their engagement during the course shows that they are eager to understand the specific challenges and learn about possible solutions.

The concept of “teaching by consideration of examples” and following the HiBERatlas helps students internalize the two steps – to first understand the building, its values, challenges and potentials and then develop a targeted retrofit concept and select suitable retrofit solutions. Working each student with a real building and having direct contact to engaged architects and owners allows to bring the theoretical inputs to "real world experience" and thus remember them more easily. The wide range of historic buildings covered by the group, which ideally includes both listed and not listed buildings, different challenges and potentials and thus a variety of solutions chosen, consents them to recognise that there are no "one-fits-all" solutions. This should provide them with the awareness and qualification needed to enter in a dialogue with all stakeholders, aim for the "best possible" and claim for the negotiation space also promoted by Herrera et al [10].

Having involved the building owners as clients besides the architects has proven to be an important aspect. Their enthusiasm and commitment can be very motivating –on the other hand side, they do also give feedback on how they experience living in the retrofitted building, what works well, what is missing, how decisions were reached – in short the client's view of the retrofitting process. What we still consider an added value is a concrete involvement of heritage agencies, beyond the reviewers feedback described above.

Finally, next to the learning effect, the students get to know in the HiBERatlas a source for ideas and will hopefully themselves contribute to its growths sharing their own successful retrofit projects.

6. References

[1] Troi, A. 2011, Historic buildings and city centres – the potential impact of conservation compatible energy refurbishment on climate protection and living conditions, *Int. Conference Energy Management in Cultural Heritage*, Dubrovnic, April 2011
[2] CEN 2017, Conservation of cultural heritage – guidelines for improving the energy performance of historic buildings, EN 16883:2017, Comité Européen de Normalisation (2017), Brussels.
[3] Timmermans, Frans 2021, Keynote speak at Callaway Climate Insights' first Dublin Climate Summit, cited online in https://www.independent.ie/business/irish/historic-buildings-face-huge-climate-change-challenge-timmermans-40139109.html [visited on 6.3.2021]
[4] Von der Leyen, Ursula, 2020, State of the Union Address 2020 on 16.9.2020, avilable online https://ec.europa.eu/info/sites/info/files/soteu_2020_en.pdf [visited 6.3.3021]
[5] Europa Nostra 2020 *Cultural Heritage as an integral dimension of the "New European Bauhaus" initiative*, statement published online [visited on 6.3.2021] https://www.europanostra.org/wp-content/uploads/2020/12/202012-New-European-Bauhaus_Europa-Nostra-Statement.pdf
[6] Architects Council Europe 2020, Making the Renovation Wave a Cultural Project, statement published online https://www.ace-cae.eu/fileadmin/user_upload/BH_statement_FINAL-2.pdf [visited on 6.3.2021]
[7] Davos Declaration 2018, Towards a high-quality Baukultur for Europe, available online https://davosdeclaration2018.ch/ [visited 6.3.3021]
[8] Femenías, P. 2004, Demonstration Projects for Sustainable Building: Towards a Strategy for Sustainable Development in the Building Sector Based on Swedish and Dutch Experience, Chalmers University of Technology, Goteborg
[9] Lidelöw, S., Örn, T., Luciani, A. and Rizzo, A. 2019, "Energy-efficiency measures for heritage buildings: a literature review", Sustainable Cities and Society, Vol. 45, September, pp. 231-242.
[10] Herrera-Avellanosa, D., Haas, F., Leijonhufvud, G., Brostrom, T., Buda, A. Pracchi, V., Webb, A., Hüttler, W., Troi, A. 2019, Deep renovation of historic buildings: The IEA-SHC Task 59 path towards the lowest possible energy demand and CO2 emissions", *International Journal of Building Pathology and Adaptation*, Vol. 38(4), pp. 539-553
[11] Historic Building Energy Retrofit Atlas https://www.hiberatlas.com [visited on 6.3.2021]
[12] ITAS Preis für vorbildliche Sanierung bäuerlicher Gebäude, Bauern(h)auszeichnung, http://itaspreis.gruppoitas.it/ [visited on 6.3.2021]

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