Attractive, Acceptable and Affordable deep Renovation by a consumer orientated and performance evidence-based approach

Contract No.: 784972

Report: D2.1 Report on architectural determinants of building performance

Work Package: WP2 – Task 2.1
Deliverable: D. 2.1
Status: public

Prepared for:
European Commission
EASME
Project Advisor: Rebecca Kanellea

Prepared by:
ACE: Dr. Veronika Schröpfer

Contributors:
HIA: Dr. Simona D’Oca
IRI UL: Jure Vetršek, Gregor Cerinšek
COM: Gabor Nemeth, Dr. Zoltan Magyar
UNIBO: Dr. Davide Prati
IVE: Ana Sanchis
ACE: Larissa De Rosso
Revision and history chart:

<table>
<thead>
<tr>
<th>VERSION</th>
<th>DATE</th>
<th>EDITORS</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 0.1</td>
<td>2018-12-20</td>
<td>ACE</td>
<td>First outline draft provided</td>
</tr>
<tr>
<td>Version 0.2</td>
<td>2019-02-15</td>
<td>COM, HIA, IRI UL, IVE, UniBo</td>
<td>Contributions received and integrated</td>
</tr>
<tr>
<td>Version 0.3</td>
<td>2019-03-28</td>
<td>COM, HIA, IRI UL, IVE, UniBo</td>
<td>Second round of contributions received and integrated</td>
</tr>
<tr>
<td>Version 0.4-0.9</td>
<td>2019-04-24</td>
<td>ACE, IVE</td>
<td>Various rounds of contributions integrated</td>
</tr>
<tr>
<td>Version 1.0</td>
<td>2019-04-29</td>
<td>ACE</td>
<td>Final version submitted to coordinator</td>
</tr>
</tbody>
</table>
# Table of contents

1. Executive summary ........................................................................................................ 5
2. How and what to measure? An up-date on key trends and metrics ..................................... 7
3. Research projects examining the criteria ........................................................................ 12
4. Compilation of the results of the identified research projects ........................................ 15
   4.1 Level(s) ...................................................................................................................... 15
   4.2 ALDREN ................................................................................................................... 15
   4.3 ABRACADABRA ...................................................................................................... 16
   4.4 MOBISTYLE ............................................................................................................ 16
   4.5 P2ENDURE .............................................................................................................. 16
   4.6 BRESAER ................................................................................................................ 17
   4.7 SSO ........................................................................................................................ 17
   4.8 NeZeR ...................................................................................................................... 18
   4.9 New TREND ............................................................................................................. 18
   4.10 EASEE .................................................................................................................. 19
   4.11 OPEN HOUSE ....................................................................................................... 19
   4.12 SUPERBUILDINGS ............................................................................................... 19
   4.13 PERFECTION ........................................................................................................ 20
5. Smart buildings and the Smart Readiness Indicator ............................................................ 22
   5.1 Smart building features/ ICT and benefits for the occupants ...................................... 23
   5.2 The Smart Readiness Indicator for Buildings ............................................................. 25
   5.3 The ACE Policy Position on the Smart Readiness Indicator ....................................... 28
6. Teaching the value of architecture for building performance ............................................ 32
   6.1 A European Overview ............................................................................................. 32
   6.2 HUNGARY (Budapest) ............................................................................................ 42
   6.3 SPAIN (Valencia Region) ........................................................................................ 43
   6.4 ITALY (UNIBO - Alma Mater Studiorum - University of Bologna) ............................ 45
   6.5 SLOVENIA (University of Ljubljana) ...................................................................... 48
7. Best practice examples ...................................................................................................... 49
   7.1 Case 1: Rochestown House ...................................................................................... 49
   7.2 Case 2: BUILDSMART Site Bilbao .......................................................................... 50
   7.3 Case 3: EU-GUGLE Site Sestao .............................................................................. 51
7.4 Case 4: ZENN Site Eibar ................................................................. 53
7.5 Case 5: HAPPEN Site Castellón ...................................................... 54
7.6 Case 6: e2ReBuild, Munich ........................................................... 56
7.7 Case 7: Tour Bois Le Pretre, Paris ................................................ 58
7.8 Case 8: Vejgaard residential district, Aalborg .................................. 60
7.9 Case 9: Tower Weberstrasse, Winterthur ....................................... 61
7.10 Case 10: Residential Building in Doha, Qatar ................................ 63
7 Conclusion ....................................................................................... 64
8 References ...................................................................................... 65
9 Appendix 1: Selection of courses that include the value of architecture in Europe ........................................... 68

List of Tables
Table 1. Criteria of good architecture.......................................................... 10
Table 2. EU funded projects related to the value of architecture ................. 12
Table 3. Taught Criteria Areas of good architecture per country .................. 34
Table 4. Measured and/or calculated values before and after the renovation .... 56

Table of Figures
Figure 1 The seven main areas influenced by ‘good’ architecture .................... 5
Figure 2: Scope of Smart Building (source: IBM) .......................................... 23
Figure 3: Overview of the SRI methodological framework ............................ 26
Figure 4: Participating European Architecture Schools in the survey ............ 32
Figure 5: The ranking of the seven main areas of ‘good’ architecture taught at EU Architecture Schools .... 35
Figure 6: The ranking of the taught criteria ................................................ 36
Figure 7: The ranking of the Heritage criteria .............................................. 36
Figure 8: The ranking of the Well-being criteria ......................................... 37
Figure 9: The ranking of the Cultural criteria .............................................. 37
Figure 10: The ranking of the Functional criteria ........................................ 38
Figure 11: The ranking of the Social criteria ............................................... 39
Figure 12: The ranking of the Ecological criteria ........................................ 40
Figure 13: The ranking of the Economic criteria ........................................ 40
1 Executive summary

There is an intrinsic understanding that ‘good’ architecture defines the long-term functionality and resilience of buildings and that it has a strong bearing on building performance. However, it is not considered ‘measurable’ and it rarely features as a quantifiable value driver in investment cycles and legislation. This report aims at establishing a baseline on how architectural solutions can support building performance and be market drivers for owners during the decision-making process. In order to be coherent with the TripleA-reno project, the focus lies on architectural services of retrofitting the existing building stock and the value therein for occupants.

As a matter of fact, the latest assessments of the European energy strategy for 2030 targets show that energy efficiency and building renovation targets in the residential sector are not being met with a sufficient pace. This implies that sustainable homes are nothing but buzzwords without considering the need and wish of the residents within. Too often we forget for whom buildings and innovative technical systems are intended. The TripleA-reno project is adopting a people-centred approach to reduce final energy usage in the residential EU building stock, thus going beyond the limited focus on technology-driven solutions alone. This approach is supporting the upcoming perception within the field of energy and buildings that people (and not buildings) consume energy. This includes the important effect of the behaviour of people living in buildings together with the values, habits and motivation factors connected to energy usage. In a broader perspective, these human factors are responsible for the success of reduced energy consumption, enhanced building performance and user comfort and health, must be taken into consideration.

The University of Reading (UK) has consolidated a strategic report on existing knowledge demonstrating the value of design and the role of architects across Europe (Callway, et al., 2019) simultaneously to this study. Post Occupancy Evaluation (POE) is highlighted as one of the tools to enhance the user experience, yet the authors state that more information is required to better understand the users’ view of the role of Architects and the value of design (ibid).

Figure 1 The seven main areas influenced by ‘good’ architecture
Chapter 2 identifies and categorises various perceived values of architecture. The seven areas can be found in Figure 1. It is assumed that the more of the categories are covered by the architect the higher the value. All the categories touch the perception of owner/occupants. As a result, they go beyond the so-called triple bottom line of sustainability, which includes the social, ecological and economic value (Bilge Serin, 2018).

This report comprises:

1. An up-date on key trends, as well as commonalities in the metrics used to measure the value of architecture, resulting in a list of criteria allocated to seven main areas, see Figure 1.
2. A list of research projects that were identified by the involved project partners, which have taken into account the potential of ‘good’ architecture to influence the previously identified criteria.
3. Compilation of the results of the identified research projects regarding the value of ‘good’ architecture and its bearing on building performance and occupants’ satisfaction.
4. The current developments towards smart buildings and the smart readiness indicator (SRI), how it fits into the value discussion and which benefits it potentially provides to occupants.
5. An up-date on the degree to which the value of architecture is taught in European architecture schools.
6. Various best practice examples of architectural and building performance excellence in residential retrofitting projects.

In summary, this report examines the value of architecture, which criteria it involves, to which extent was it already researched, are universities in Europe teaching it and are there best practice examples.
2 How and what to measure? An up-date on key trends and metrics

When investigating the value architecture can bring to a building, it becomes clear the value goes beyond the building scale, affecting its occupants, owners, investors, neighbours, the whole community, district, city and nature beyond. This leads to various types of value, such as social, environmental and economic (Serin, et al., 2018). Moreover, there are different ranges of its scale, for instance neighbourhood, urban, regional (ibid). Besides, the product of design value is not only the building, but also the building process, which can be positively and negatively affected by good design. In fact, there is little doubt that ‘good’ or ‘high quality’ architecture is a public good, one that creates positive externalities for the surrounding structures and communities (Bourassa, et al., 2004). This concept of quality architecture as a public good explains, in part, the existence of historic districts, design reviews, planning boards, and government-imposed aesthetic requirements for permitting (Millhouse, 2005).

Yet, the question remains, what is the unit, the currency of this value?

Architectural value cannot be simply calculated in money, as the value of design varies per stakeholder dramatically. On the one hand, it is measured in money for an investor, in terms of higher rental value, increased asset value, less maintenance and better resale value, just to mention an few (Millhouse, 2005). On the other hand, the developer profits of good design in terms of quicker permissions, a more efficient and safe construction process, increased public support and generating a good reputation. Whereas for the occupant the benefits include e.g. fewer disruptive moves, reduced security expenditure, reduced maintenance costs, greater accessibility, increased occupier prestige, better health and well-being (Serin, et al., 2018). As a result, an investigation into the value of architectural design is a rather complex task, which requires consideration of the various types, scales and currency units of this value.

Therefore, in this context, we need to define the parameters involved in our valuation focus, i.e. how to measure “good design”. Furthermore, if we are considering them together or separate, and the algorithmic for aggregation. Do we aim for a normative value, for the sake of comparability, publicity and integration with other tools or just as a self-reporting information? Finally, how to approach their measuring, meaning, on which foundations to base the quantity of “good design” of a building.

Any valuation system is based on a set of principles (the foundations orienting the valuation activity), and a combination of criteria (the aspects to be measured) and methods (the techniques to get from the qualities to the quantities). The criteria guiding a valuation process are, on one hand, normative-based: administrative oriented processes are objective, based on pre-set formulations and modules, and are used for valuations that need to comply with comparability, legality or equality requirements, thus oriented to third parties/public knowledge, such as certifications, taxes or urban development; while market-oriented processes are subjective, dependent on the evaluator experience, and usually aim to inform, support or justify decision making, thus oriented to the owner/private knowledge. Furthermore, valuation processes can focus on different areas of the valuable item (Ministerio de Economía y Hacienda (MEH), 2008).

The first question that was addressed was: whose value are we looking at? Value is very subjective and depends on the stakeholder. However, even in each stakeholder group the value varies depending on subjective hierarchy of consideration. Very often the user, i.e. building occupant is overlooked. In line with the TripleA-reño objectives one way could be to define design value in relation to the user experience. It is to be noted that many studies on sustainability, but even more on health, comfort and well-being are focused
on tertiary building. Thus, studying its value, reliability and measurement in the residential context reinforces the approach of the TripleA-reno project. Moreover, the project team is working on enhancing the renovation rate, which is lagging behind in Europe. As a result, the focus is in determining how to measure the value of architecture from the perspective of occupants of existing residential buildings in the need of renovation, or currently being renovated.

Good architecture, in fact, is something that we all seek, and which is difficult to define: a combination of multiple criteria that equate to a multitude of values individuals may not completely agree upon. Vitruvius (circa 80-15 B.C.) insisted that three fundamentals should be present: function, structure, and beauty – which remains true until today. Others might argue the relationship of a building with its surroundings, cultural context and society’s expectations at the time are also important. Value for money might be added, based on cost-benefit evaluation that variously includes tangible and intangible components. Finally, Sir Alexander John Gordon, in his role as President of the Royal Institute of British Architects, defined ‘good architecture’ in 1972 as buildings that exhibit ‘long life, loose fit and low energy’ (Gordon, 1972). These characteristics, nicknamed by Gordon as the 3L Principle, are measurable.

The idea of building for permanence, incorporating flexibility to accommodate future change, minimising energy footprint throughout its physical life in an aesthetic built result, is surely the ultimate holistic objective for the architecture profession (Murray, 2011). Today these objectives may be summarised as durable, adaptable, sustainable and aesthetic. Good architecture should reflect these properties, and not merely be works of public art or a monument to their designers, technological prowess or the financial wealth of their owner (Langston, 2014). In this context, (Langston, 2014) uses a case study methodology to assess the “good architecture” of 22 projects that have won architectural design awards.

As a result, architecture’s true value may be found at the resolution of the dichotomy between economic and cultural concerns, both of which are traditionally considered to be conflicting needs (Klufas, 2003). Change in values, however, is occurring and architecture is being utilised as a tool to positively influence such diverse interests as sustainability, economic viability, and productivity, and personal well-being. Regeneration through innovative and successful architecture should be integrally involved in a renewed vitality of urban life and culture (Warpole, 2000). Architecture’s true value is its ability to accommodate these interests. (Bole & Reed, 2009) encourage discourse and discussion about the different forms of value and how it is perceived in an architectural sense, considering that there are numerous classifications and perceptions of value in our society, which are in a constant state of change, and it is imperative that we regularly re-evaluate the relevance of these ever-changing values to design in regards to:

- **The economic value of good architecture** could bring a prime cost reduction, skills and expertise of the architect can provide cost-effective solutions to complex problems, not only saving money, but providing extra benefits in terms of increased space, easier access, more efficient working and living conditions (Carmona, et al., 2002). Additionally, lifecycle costs can be reduced, since clients are interested not just in the productivity of the building process, but also in the occupancy costs in relation to their own economic objectives. Clients are now becoming interested in a new and most important concept: measuring the productivity of building use through time (Loe, 2000). Costs can also be saved through better management. Bringing together a multi-disciplinary team consisting of designers, cost consultants, representatives from client organizations, end users, stakeholders, and, in some circumstances, members of the wider community in order to identify the purpose of the project itself and the activities it is to accommodate (Loe, 2000).
Sustainability is related to the **ecological value** of architecture, taking greater regard for the orientation of the site, local topographical and environmental factors, and designing and fine-tuning buildings that take advantage of these to minimize energy use – and therefore revenue costs – and provide comfortable and pleasant environments in which to work and live (Bole & Reed, 2009). Also, related to them, the notion of **resilience** goes back to the 19th century and was originally based in engineering: it is the property of a material to absorb energy when it is deformed elastically and then, upon unloading, to have this energy recovered. (Tredgold, 1818) introduced the term to describe a property of timber. From an ecological perspective, (Holling, 1973) initially defined resilience as a ‘measure of the ability of ecological systems to absorb changes of state variables, driving variables, and parameters, and still persist’. Resilience engineering is concerned with building systems that are able to circumvent accidents through anticipation, survive disruptions through recovery, and grow through adaptation’ (Madni & Jackson, 2009). Therefore, resilience, as sustainability, is not a specific building attribute, which could be quantified, but a complex management process of the built environment dealing with the long-term evolution of buildings and infrastructures (Kohler, 2018). Good architecture contributes to building resilience against extreme weather conditions, such as heat waves and floods, but also against critical events such as earthquakes.

**Social value of architecture** lies in delivering more liveable, sociable spaces (Serin, et al., 2018). Good design may lead to lower crime rates, lower demand on health provision, and possibly even better educational attainment in the long term (Warpole, 2000).

Most criteria found in literature are related to the **functional value** of good architecture. Good design layouts could support a longer life-cycle of the building and for a user’s whole life cycle. Examples could be an enhanced functionality/ fit for purpose/ loose fit. Also improving daylight access, considering the floor to ceiling height in order to improve the user’s experience, use building mass to improve thermal comfort can be influenced by design. In addition, the safety for occupants and construction workers (prevent fire, minimize earthquake/flood damages) can be improved by good architecture.

Architecture’s **cultural value** lies in its nature as a public good or externality, affecting positively and negatively both the inside and the surroundings. These effects are usually determined by those who commission the building, often through a lack of awareness or care. The **cultural value** of good architecture is increasing the community value and hence strongly linked to the social value. It could be found for instance in an improvement of the public realm quality, a raise the community cohesion and activities or the provision of better public amenities (i.e. parks, fountains, electrical charging, benches, sport facilities).

The value area of **health and well-being** and its relation to productivity, given the ability of buildings to provide heat and coolness, light and shade, companionship and sanctuary, excitement and rest. It has been demonstrated that buildings, which actively pursued sustainable design, have also enhanced the occupants’ perception and use of the building, which in turn has increased its economic value, as well as its social sustainability (Myers, et al., 2008). The health-related value of an architectural design is most vital for the user/ occupant. In the last years, the sustainable building design has moved from an energy efficiency centric to an occupant experience centric approach (Steemers, 2003), trying to link sustainability rating systems with comfort of occupants and conservation of natural resources (Liang, et al., 2014). The research in the area of sustainable building design and the well-being of the user focus on energy performance, daylight, ventilation, acoustics and occupant feedback (Paul & Taylor, 2008).
However, this should be taken with caution, since well-being and comfort of occupants could be in conflict with the performance of the building: as discussed in (Al horr, et al., 2016) green building designs do not automatically guarantee that the building designed will be comfortable and ensure occupant well-being; and just designing a potentially comfortable building is also not enough; thus, we will need to monitor both building and occupant performance during its operations. In this context, (Mateo-Cecilia, et al., 2018) analysis of the state of the art determines that four factors are widely considered to characterize the acceptability of an indoor environment: indoor air quality (IAQ), noise, lighting and thermal comfort. In order to assess comfort and health conditions, international organizations and research institutions have developed standards to define the acceptable ranges of the main IEQ (indoor environmental quality) parameters, but, these ranges are not universally applicable across all building types, climates, and populations, and there are some key aspects linking overall satisfaction with IEQ, such as the type of job and the country of origin, which have not been pondered by standards. Other aspects such as the level of education, the psychosocial atmosphere and time are also important and have not been studied enough in the built environment field.

- Architects add value to cultural/ built heritage in terms of an increase in building resilience/durability by protecting the building character, enhancing the building preservation and proposing an integration with the surrounding environment

To ease the overview of the various values of good design, found in literature (e.g. (Samuel, 2018); (Serin, et al., 2018)), and discussed above, they were grouped into economic, ecological, social, functional, cultural, health and heritage values. It appears that good design influences all seven areas. Table 1 comprises all identified values.

**Table 1.** Criteria of good architecture

<table>
<thead>
<tr>
<th>economic</th>
<th>ecological</th>
<th>social</th>
<th>functional</th>
<th>cultural</th>
<th>health</th>
<th>heritage</th>
</tr>
</thead>
<tbody>
<tr>
<td>- increase in Real Estate value - Raise occupant productivity in tertiary buildings - facilitate real estate project funding/investment - lower the risk of gentrification - ensure a cost-efficient budget/ construction process.</td>
<td>- improve the urban environmental quality - provide sustainable environments - support biodiversity - deliver an efficient resource use - increase the environmental value - mitigate climate change - reduce pollution - reduce carbon emission</td>
<td>- create liveable places - support communities’ identities and create a sense of belonging - enhance visual appearance of the built environment creating a visual value for the community - provide inclusive spaces that support diversity</td>
<td>- improve safety for occupants and construction workers (prevent fire, minimize earthquake/flood damages) - improve accessibility - enhance functionality/ fit for purpose/ loose fit - increase the urban quality experience - improve navigation through spaces - enhance building legibility (the degree where the use of</td>
<td>- increase the community value - improve the cultural value - enhance the public realm quality - raise the community cohesion and activities - provide better public amenities (i.e. parks, fountains,</td>
<td>- improve healthy and active lifestyles - increase the visual aspect and influence the feeling of self-worth - improve indoor air quality - improve indoor environmental quality - improve acoustic comfort - improve lighting comfort</td>
<td>- increase building resilience/durability - propose an integration with the surrounding environment - protect the building character - support the heritage value/ legacy - enhance the building preservation</td>
</tr>
</tbody>
</table>
- enhance the natural landscape
- provide efficient and effective water/waste management solutions
- reconnect people to nature through biophilic design
- improve Life Cycle Assessment (LCA)

- address active ageing design for elderly
- provide strategies to prevent deprivation
- provide strategies to prevent crime
- be socially sustainable
- provide a social return of investment
- increase occupant satisfaction by Post Occupancy Evaluation

- the building could be easily understood
- improve the flexibility and adaptability of layouts for a longer life-cycle
- improve urban strategies for active transport
- enhance urban strategies for public transport
- increase alternatives to reduce car dependency
- improve buildings for a user’s whole life cycle
- improve daylight access
- consider the floor to ceiling height in order to improve the user’s experience
- use building mass to improve thermal comfort

- improve thermal comfort
- select materials and textures that positively influence people’s mental health and well-being

Summing up, by identifying the value criteria of ‘good’ architecture, one might say we have defined the currency or unit of it and are able to evaluate it better. Meaning, the more of these criteria are positively affected, the better the architecture, hence the higher its value. Evidently the research limitation lies in the ever-changing nature of the building process and built result through e.g. digitalisation and innovative technology, leading to ever changing criteria and their definition. For instance, energy efficient buildings changed to low energy buildings, then to nearly zero energy buildings, passive buildings and currently moving towards positive energy buildings and smart buildings. Hence a criterion on energy efficiency has to amend in its definition. Whereas other criteria, relating to economic or social themes might rest unchanged. Nevertheless, the above identified criteria provide a sort of check-list, which enables a holistic assessment of the value of architecture especially from the occupants’ perspective.

The value criteria have been used as a basis for an online survey amongst European architecture faculties and departments. The aim was to investigate to which extent these aspects of ‘good’ architecture are taught to students and researched. The results of the questionnaire analyses are discussed in section 6.1.

Moving on, the project team created a core database of EU funded projects, that were looking into the various criteria, which are summarised in Chapter 3. This was undertaken in order to investigate whether
there were any reports/ findings/ outputs on the identified criteria and if/ how were these measured, which will be elaborated in Chapter 4.

3 Research projects examining the criteria

This chapter consists of a list of research projects that were identified by the involved project partners as the ones that have taken into account the potential of ‘good’ architecture to influence the previously identified criteria.

Table 2. EU funded projects related to the value of architecture

<table>
<thead>
<tr>
<th>Project</th>
<th>Architectural Value Criteria</th>
<th>Project website</th>
<th>Link to results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level(s) (on-going)</td>
<td>voluntary reporting framework with six key areas: greenhouse gas emissions, resource efficiency, water use, health and comfort, resilience and adaptation, and cost and value</td>
<td><a href="http://ec.europa.eu/environment/eussd/buildings.htm">http://ec.europa.eu/environment/eussd/buildings.htm</a></td>
<td><a href="http://ec.europa.eu/environment/eussd/pdf/LEVEL(S)%20CONFERENCE%20REPORT.pdf">http://ec.europa.eu/environment/eussd/pdf/LEVEL(S)%20CONFERENCE%20REPORT.pdf</a></td>
</tr>
<tr>
<td>Project</td>
<td>Description</td>
<td>Website/Links</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>NeZeR</td>
<td>Smart and integrated NZEB renovation measures for nZEB</td>
<td><a href="http://www.nezer-project.eu/">http://www.nezer-project.eu/</a> <a href="http://www.nezer-project.eu/designcompetitition.4.1f96676d145d7c93741144d.html#.XJzi3i2ZO9Y">http://www.nezer-project.eu/designcompetitition.4.1f96676d145d7c93741144d.html#.XJzi3i2ZO9Y</a> <a href="http://www.nezer-project.eu/download/18.4a88670a1596305e782d60/1487344426863/Report%20on%20design%20competitions.pdf">http://www.nezer-project.eu/download/18.4a88670a1596305e782d60/1487344426863/Report%20on%20design%20competitions.pdf</a> <a href="http://www.nezer-project.eu/download/18.76c6e08e1573302315f3866/1480075541576/1_Ups_booklet_290416.pdf">http://www.nezer-project.eu/download/18.76c6e08e1573302315f3866/1480075541576/1_Ups_booklet_290416.pdf</a></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Focus Areas</td>
<td>Website Links</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="https://www.ace-cae.eu/fileadmin/user_upload/eu_funded_projects/OPEN_HOUSE_AG1.2.pdf">https://www.ace-cae.eu/fileadmin/user_upload/eu_funded_projects/OPEN_HOUSE_AG1.2.pdf</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="https://www.hindawi.com/journals/tswj/2014/365364/">https://www.hindawi.com/journals/tswj/2014/365364/</a></td>
<td></td>
</tr>
</tbody>
</table>
4 Compilation of the results of the identified research projects

Based on the EU funded projects listed in Chapter 3, we have identified further the valuation criteria and their measurement principles and methods resulting from the developed work/research.

4.1 Level(s)

Level(s) is a voluntary reporting framework developed by the European Commission. It creates a common EU approach to assess the environmental performance of buildings.

Level(s) had identified six macro indicators, as follows:

1. Greenhouse gas emissions along building life cycle
   a. Actual building energy consumption (kWh/m²/yr)
   b. Life cycle global warming potential (CO2 eq./m²/yr)
2. Resource efficient and circular material life cycles
   a. Building bill of materials (kg)
   b. Scenarios for lifespan, adaptability and deconstruction
   c. Construction and demolition waste and materials (Kg/m²)
3. Efficient use of water resources
   a. Actual water consumption (m³/occupant/yr)
4. Healthy and comfortable spaces
   a. Indoor air quality (Ventilation rate – l/s per m², CO2 - part per million, Relative humidity - % ratio of partial to equilibrium vapor pressure)
   b. Time out of thermal comfort range
5. Adaptation and resilience to climate change
   a. Scenarios for projected future climatic conditions
6. Life cycle cost (€/m²/yr)

The indicators can be assessed in three different levels; Common assessment, Comparative assessment and Optimisation assessment.

Currently, the proposed indicators and assessments are being tested in 136 projects and a wider range of groups. Next steps will involve raising awareness and engage all actors in the programme; building capacity of industry and public authorities to practice Level(s); aligning widely used certification schemes and digital tools (such as BIM and renovation passport) with Level(s); supporting the development of national policies for more sustainable building environment. The Architects’ Council of Europe supported the development of Level(s) throughout with one expert and co-operated with the EC on the testing phase. The architects’ contribution is potentially high in all six macro indicators and relates back to all seven areas of value identified in this report.

4.2 ALDREN

The project proposal is to consolidate, promote and implement an extended harmonised procedure and a set of relevant instruments, based on the European Common Voluntary Certification Scheme for non-residential buildings (EVCS) in order to support deep building renovation of offices and hotels.
The project uses a model to simulate the energy consumption and monitors and verifies the results during the first year of operation after the deep renovation.

A certified energy performance, health and wellbeing indicators will be linked with financial and economic indicators in order to facilitate the decision make process. These indicators relate to the seven identified areas of value of ‘good’ architecture of this report.

4.3 ABRACADABRA

This three-year Horizon 2020 project focused on the market up-take on energy efficiency. (ABRACADABRA stands for Assistant Buildings’ addition to Retrofit, Adopt, Cure and Develop the Actual Buildings up to zero energy, Activating a market for deep renovation.)

ABRACADABRA is based on the prior assumption that non-energy related benefits play a key role in the deep renovation of existing buildings. In particular, the generation of a substantial increase of the real estate value of the buildings through significant energy and architectural transformation to go beyond the minimum energy performance and aim at achieving Nearly Zero Energy Buildings (nZEBs). The integration of Renewable Energy Sources systems with new volume additions or new buildings’ construction designed by an architect were investigated. Two building projects in Chapter 7, Tour Bois Le Pretre in Paris and the Tower Weberstrasse in Winterthur, were best practice examples of this project.

4.4 MOBISTYLE

The Mobistyle project aims to raise occupant awareness on the relation between user behaviour and energy consumption. The objective is to motivate a behavioural change in lifestyle in order to achieve an optimized energy use through ICT tools. A tool will inform the end-user on a combined set of information regarding energy, indoor environment, health and lifestyle. It will make the end-user more confident and conscious of which action to take in order to lower energy consumption. A game will be developed to encourage users to compare their action with other users and access past achievements. The user-centric approach goes in line with the TripleA-reno project. The set of information covers areas that are potentially effected by ‘good’ architecture during the renovation process.

4.5 P2ENDURE

P2ENDURE aims to provide pre-fabricated plug-and-play solutions for energy efficient building envelope renovations and technical systems. The new solutions are be affordable, quick to manufacture and install, easy to replicate, adaptable and compatible to most of building types across Europe. There are ten implementation sites in which the products are applied and monitored ensuring that they will be ready for use for EU-market by 2020. The façades are being developed taking into consideration architectural design solutions. Hence the value of good architecture is used in the project to define the renovation results.
4.6 BRESAER

The aim of the project is to develop a manufacture cost-effective and adaptable cladding and roof system for deep building renovation to achieve significant reduction in the primary energy consumption. The technology will also improve the indoor environment quality raising the thermal, acoustic and lighting comfort and enhance air quality.

The project developed a range of tools for every phase of the design. In early stages, BER-DES tool helps to estimate the energy savings provide by the BRESAER system. During the technical design a BIM based tool provides straight forward feedback on buildability and cost. Finally, during use, BEMs tool is able to monitor and assess the energy savings after the implementation of BRESAER system. One of the final results of this project is a tool for architects to support their decision-making processes.

4.7 SSO

Smart and Sustainable Offices (SSO) pan European initiative was a Climate-Kic project which started in the beginning of 2014 and lasted for four years (December 2017). SSO’s main goal was to investigate work interior environments that positively affect users (health values) and reduce overall costs (economy values) while reducing energy consumption (ecology values).

The SSO hypothesis is that improving physical working conditions can improve productivity and innovation processes without increasing energy consumption. In order to define an SSO valid model (valuation criteria), the first step was to test the relationships between the office’s indoor environmental quality (IEQ) parameters, energy consumption and employees’ well-being, health and performance by carrying out empirical studies in different climates, different seasons, in real case scenarios.

Variables studied were (mostly ecology and health related values):

- Noise, Lighting, Temperature
- Positive emotions, Negative emotions, Flow
- Activity worthwhileness
- Health symptoms
- In-role, Extra-role

Where means, standard deviations, minimum values and maximum values and their correlations were studied (measurements principles and methods), resulting in a certification scheme and design guidelines, which can be regarded as a valuation system, including three main categories:

- Environment: energy efficiency & sustainability (ecological value)
- Health and well-being: IAQ, noise comfort, thermal comfort & lightning comfort (health value)
- Spatial quality: patterns, appliances, look & biophilia & accessibility (functional value)

Therefore, an approach to architectural/design evaluation through a compound of indicators was applied and demonstrated in this project, focused on the functional, ecological and health values, together with their related calculation methods. However, the final relationship between the certification rating and its
monetary/ productivity/ absenteeism measurement was missing (economical value), and thus, it supports this report’s vision and mission.

More information:


http://www.five.es/descargas/archivos/BES_oficina/Resumen_GUIA_BES_OFICINA_V_2_0_B171220.pdf

4.8 NeZeR

The project promoted the implementation of Nearly Zero Energy Building Renovation in the European Market in order to increase the awareness on its advantages to all stakeholders in the design and construction chain. The project delivered several outcomes, such as the analyses and presentation of case studies, which implemented technical solutions for renewable energy sources in nZEB renovation, feasibility studies and environmental and economic assessments between traditional and nZEB renovation, guidelines for city plans to implement nZEB renovation, and training workshops and competitions to improve knowledge about nZEB renovation on the construction chain.

An architectural design competition was undertaken in Finland. The winner proposal was the renovation of a post war residential block targeting the improvement of living conditions for the residents and increasing the social value by implementing community spaces and shared/common areas. The team looked in depth at proposals for renewable energies, passive strategies for daylight and thermal comfort, ventilation strategies and building materials. They also analysed the life cycle cost of the base case scenario and the nZEB renovation scenario and estimated a renovation payback time.

More information on Finland’s winner can be found under the link below.

http://www.nezer-project.eu/designcompetition.4.1f96676d145d7c93741144d.html#.XJzi3i2ZO9Y

4.9 New TREND

New TREND developed an integrated retrofit design methodology and tools for energy efficient buildings. The tool for all stakeholders promotes a participatory design process from conceptual design phase to post occupancy evaluation phase. The includes a library with information on different energy efficient construction techniques, as well as a platform for 3D model and energy simulations.

The project highlights the advantages of the engagement of all stakeholders and mainly the end-users. This involvement with the occupants provides feedback to the professionals in order to create design solutions that better address the occupants needs. As a result, occupants can understand better their home functionalities and technologies, are more conscious on their energy-saving/ use of their homes.

This project goes very well in line with the user-centric approach of TripleA-reno. Furthermore the design process is highlighted, adding to the perceived value of architects, if they follow a participatory process.
4.10 EASEE

EASEE created a tool-kit for façades retrofitting in order to create an energy efficient envelope for multi storey and multi-owner buildings built before the seventies. The technical prefabricate modular solution for internal and external renovation were tested in laboratory and trough virtual environment models and later validated in buildings in different countries. A Design software tool was created to assist architects in the detail design stage.

4.11 OPEN HOUSE

OPEN HOUSE developed and implemented a building assessment methodology common to all European Member States to assist the planning and construction of sustainable buildings. The assessment is done in six main categories: environmental, social/functional and economic quality, technical characteristics, process quality and location. Each category has a calculated scoring system and an assessment methodology. This project took place before Level(s) was developed and the Architects’ Council of Europe was a consortium partner. The assessment categories reflect the in this study identified areas of architectural value.

4.12 SUPERBUILDINGS

SUPERBUILDINGS (Sustainability and performance assessment and benchmarking of buildings) was a European Seventh Framework Programme for Environment which started in the beginning of 2010 and lasted for three years until the end of December 2013.

The main objectives of SUPERBUILDINGS were, among others:

- to develop the potential of sustainability assessment and benchmarking methods (measurements principles and methods) in progress towards a sustainable built environment,
- to develop indicators (valuation criteria) for assessing the environmental, social and economic performance of buildings,

The focus was to develop a common understanding about assessment methods and performance levels paying special attention on the validity of indicators and the comparability of assessment results. The focus of the work was on the following issues: validity, reliability, comparability, assessment method in design and operation, quantitative and qualitative methods and applicability.

In this context, one of the objectives of SUPERBUILDINGS was to develop knowledge on typical performance levels. Seven key indicators were selected for that purpose, and these were the objects of an inventory of accurate and actual data, based on statistical studies, regulation standards, voluntary schemes, or even case studies, across seven European countries (mostly ecology and health related values):

- Land Use
- Energy Consumption
- Greenhouse gas emissions
- Water Consumption
• Waste production
• Hygro-thermal comfort
• Indoor Air Quality

Another objective of the SUPERBUILDINGS project was the development and establishment of principles for the design of new systems or further development of existing systems for describing, measuring and reporting the sustainability of buildings and facilities. These principles may be applicable both during the planning stage of new buildings or at the time of delivery for demonstrating the quality of a property to third parties, as well as in the evaluation and up-grading of existing buildings. For this reason, a systematic approach is needed that results among others in an appropriate structure of assessment systems. The reason for dealing with this issue is the fact that although numerous sustainability rating systems already exist in EU, many countries face the question of whether and how to develop and apply a customized assessment system that suit the regional characteristics. The possible benchmark values depend on the type of the benchmark and can be outlined as follows:

- Target values: political targets, technical optimum, economic optimum
- Best practice value: best practice, upper quartile
- Reference value: median value
- Limit value: legal minimum, prescriptive minimum

The project showed that there is a lot of common understanding, especially locally, about the typical and best performance values of different building regarding certain sustainability indicators. However, much work is still needed to improve understanding of benchmarks and also to develop good processes for the determination of benchmarks.

Therefore, an approach to architectural/design evaluation through a compound of indicators was applied and demonstrated in this project, focused on the ecological and health values, together with the study of existing calculation methods; concluding that local actors were aware of their goals, but also that there was still work to do regarding the quantification and standardization of their related value, and thus, supporting this report’s mission.

More information:


https://cordis.europa.eu/project/rcn/93577/reporting/en

4.13 PERFECTION

PERFECTION (Performance indicators for health, comfort and safety of the indoor environment) was a European Seventh Framework Programme Coordination Action for Comfort, Health and Safety of the Indoor Environment which started in the beginning of 2009 and lasted for three years. The goal was to help enable the application of new designs and technologies that improved the impact of the indoor built environment on health, comfort, feeling of safety and positive stimulation. To reach this objective an indicator framework
(valuation criteria), as well as assessment tools (measurement principles and methods) based upon the framework were developed.

In this context, an important task focussed on the use of indicators and the way they could stimulate the development and the uptake of new designs and technologies.

The developed indicator framework, which was called the PERFECTION key indoor performance indicators (KIPI) framework, was structured in a hierarchical way and was divided into four main categories and eight sub-categories:

- health and comfort (health value)
- safety and security (functional value)
- usability and positive stimulation (functional, social values)
- adaptability and serviceability (social, heritage values)

The framework and evaluation methods form the basic elements of the PERFECTION assessment tool. The target groups for this tool are end users (individuals, builders, designers, etc.), whose design decisions will be supported. The evaluation tool gives to registered users the possibility to execute an evaluation (value measurement) of their buildings. The evaluation process is currently as follows:

- input generic data
- select the indicators to be evaluated and determine the importance of each category (critical, important, standard, marginal)
- rate indicator in accordance with the methods developed in parallel with the framework and indicate the relative importance of the evaluated indicator (critical, important, standard, marginal)
- system produces a report in which the indicator coverage, the scores and the weights are clearly written

The PERFECTION project enabled the consortium to put indoor performance as a concept on the forefront of the building value: PERFECTION KIPI Framework, the toolbox and DSS software and the promotional tool for products and technologies were applied in a series of case studies with positive results from the point of view of assessment and monitoring.

Therefore, an approach to architectural/design evaluation through a compound of indicators was applied and demonstrated in this project, focused on the functional, social, heritage and health values, together with their related calculation methods; and thus, supporting this report’s vision.

More information:

http://www.irbnet.de/daten/iconda/CIB_DC23312.pdf

https://cordis.europa.eu/project/rcn/89309/reporting/en
5 Smart buildings and the Smart Readiness Indicator

When looking at the architectural value for occupants, one cannot omit considering emerging technologies and how they interact with the architecturally designed building. Are they contributing a benefit for the occupant? Are they all necessary or can passive design measures replace some? What are the potential drawbacks and risks in this current movement?

Intelligent buildings have been researched and developed over the last three decades, but in more recent literature, roadmaps and industrial reports the term “smart” has started to be quoted more regularly. This seems to be the case in all aspects of the built environment sector; smart sensors, smart materials and smart meters within buildings are seen to be the latest, most advanced technologies in our efforts to develop high-performing buildings (Buckman, et al., 2014).

The revised Energy Performance of Buildings Directive (EPBD) was published in the Official Journal of the European Union in 19 June 2018 and entered into force 20 days after publication. The transition period for the Member States to implement the revised EPBD is 20 months. Two of the main objectives of the revised EPBD are:

1. to encourage the use of information and communication technology (ICT) and smart technologies to ensure buildings operate efficiently;
2. to introduce a “smart readiness indicator”, which will measure the buildings’ capacity to use new technologies and electronic systems to adapt to the needs of the consumer, optimise its operation and interact with the grid.

According to the revised EPBD the Commission shall adopt a delegated act by establishing an optional common Union scheme for rating the smart readiness of buildings by 31 December 2019 (European Environment Agency, 2013). This optional common Union scheme for rating the smart readiness of buildings shall establish the definition of the smart readiness indicator and establish a methodology by which it is to be calculated.

The upcoming act will establish the accurate definition of smart building. Currently, the definition of smart buildings can only indirectly be determined from the revised EPBD, which is the following: a smart building is such a building, which adapts the operation to the needs of the occupants (e.g. control of HVAC, lighting systems, building elements like shading, openings), and to the grid (e.g. demand response, smart meter), and use information and communication technologies and electronic systems (e.g. building management system accessible via the internet).

Other definitions for smart building and smart building technology can be found in literature. In 2015, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) published a handbook, which title is “Smart Building Systems”. Referring to this handbook the smart building has building components that exhibit characteristics analogous to human intelligence. These characteristics include drawing conclusions from data or analyses of data rather than simply generating more data, interpreting information or data to reach new conclusions, and making decisions and/or taking action autonomously without being explicitly instructed or programmed to take the specific action.

In summary the concept of Smart Building could be defined as a set of communication technologies enabling different objects, sensors and functions within a building to communicate and interact with each other and also to be managed, controlled and automated in a remote way. Indeed, technologies help to connect a
variety of subsystems that originally operated independently. Automated processes allow the control of the building’s operations including HVAC (Heating, Ventilation, Air Conditioning), lighting, security and other systems.

![Smart Building Subsystems](image)

**Figure 2: Scope of Smart Building (source: IBM)**

According to (Erickson, et al., 2011), in order to achieve energy savings on HVAC, real time occupancy data is critical, and it can get a 10 - 42% annual energy savings compared to the current state of the art baseline strategy. According to elektormagazine.com, a 10% reduction of the space needed for workplaces in a 10,000 m² office can save as much as 1,000,000 EUR per year taking into account that 50% of available desks are unused in France due to teleworking. The major motivation from building occupants/managers to implement smart solutions remains the reduction of electricity bills ahead of any environmental concerns. A study led by the American Council for an Energy Efficient Economy finds a cost saving of 24-32% when using smart HVAC and smart lighting. As argued in Chapter 2, it has to be noted that many studies on sustainability and smart building, such as (Liang, et al., 2014), (Paul & Taylor, 2008) or (Mateo-Cecilia, et al., 2018), are focused on tertiary building; thus, studying its value, reliability and measurement in the residential context reinforces the approach of the TripleA-reno project.

### 5.1 Smart building features/ ICT and benefits for the occupants

The design and adoption of novel information and communication technologies (ICT) towards achieving higher levels of energy efficiency in the buildings sector is considered promising. ICT has the potential to enable a 20% reduction of global CO2 equivalent emissions by 2030, holding emissions at 2015 levels as stated in the Global e-Sustainability Initiative SMARTer2030 report (Global e-Sustainability Initiative (GeSI), 2015). The application of ICT-enabled solutions is going to provide residents with greater insight and control, and an enhanced living experience whilst saving energy and resources. However, the application of novel ICT technologies for energy efficiency has also to rely on people adjusting their energy consumption behaviour. As stated in the report of the European Environment Agency (European Environment Agency, 2013), up to 20% of energy savings can be achieved through different measures targeting consumer behaviour.
Towards the design of such solutions, the identification of the main energy consuming factors, trends, and patterns, along with the appropriate modelling and understanding of the occupants’ behaviour and the potential for the adoption of environmentally-friendly lifestyle changes have to be realized. In (Fotopoulou, et al., 2017), an innovative energy-aware information technology (IT) ecosystem is presented, aiming to support the design and development of novel personalized energy management and awareness services that could lead to occupants’ behavioural change towards actions that could have a positive impact on energy efficiency.

In (Morvaj, et al., 2011), the potentials of smart buildings as the basic building block of cities, such as demand side management capabilities, micro renewables, micro energy storage, or basic electricity-price based consumption control, have been scrutinized and put into perspective.

In the residential sector, the so-called smart homes can be categorised based on their area of focus, such as energy, information and communication, security, health, environmental, home entertainment, and domestic appliances. (Kamel & Memari, 2019) review different types of energy smart homes under three major groups: homes with energy-monitoring systems, systems with control capabilities, and systems with advanced data-processing capabilities. Smart homes with energy-monitoring systems merely provide the total or granular energy-consumption data of the house by using equipment such as in-home displays, whereas systems with control capabilities also include a control unit that can send proper signals for either passive or active measures, such as appliance on/off commands. In contrast, systems with advanced data-processing capabilities include an advanced central processing unit that can provide more complicated analysis results, such as systems that are equipped with an optimization algorithm to optimize the temperature or appliance schedules based on the residents’ comfort level and energy cost.

Smart building features provide several benefits for the occupants. Smart building technologies require less manual interactions to control technical building systems, which is on one hand convenient for the occupants, and on the other hand saves energy. Smart building technologies may cover the following areas and functions usually with the usage of a building management system:

- **Optimized control of heating, cooling and ventilation systems**

  In the heating and cooling system, an intelligent thermostat can be used: the self-learning thermostat takes into account the room’s thermal characteristics to determine the time required for heating / cooling the room at a given temperature, and learns with present attitudes to find out during which periods are occupants in the building, thereby optimizing energy consumption for heating and cooling.

- **Automatic operation of shutters**

  Smart buildings may ensure automatic operation of shutters in accordance with heating and cooling systems, and depending on external influences, e.g. solar radiation intensity on the façade, nighttime thermal protection below a given outdoor temperature.

- **Control of the lighting system**
LED light fixtures have a longer life-span, adjustable illumination and ensure lower energy consumption up to 60%. Controlling the brightness of lamps is based on the outdoor illumination or according to the occupants’ needs.

- **Monitoring energy and water consumption**
  Measuring, displaying and storing the energy and water consumption data gives the opportunity for analysing the consumption trends, which helps the occupants to become more conscious consumers. The smart building system can indicate water leakages as well.

- **Monitoring IAQ parameters**
  This feature means the ongoing measurement of the indoor air temperature, relative humidity and contaminant data to inform occupants about their air quality. This feature helps the users to maintain good indoor air quality parameters.

- **Smart meter and demand response for public utility signal by load shedding or shifting**
  The smart meter is suitable for transmitting and receiving data. The data covers the amount of consumption and the price of the service used. Smart meters provide real-time information on the use of the service for both, consumers and service providers. Consumers can keep track of their current consumption and change it based on the data. In the demand response programs the building has smart meters with communications and ability for the building automation system to accept an external price or control signal.

- **Security system**
  The smart building system may include a security system as well, which for example can detect and send an alarm when intrusion into the building is taking place.

- **Convenient functions**
  Smart buildings may provide convenient functions especially in residential buildings, such as voice control of HVAC systems, or remote control of technical building systems.

### 5.2 The Smart Readiness Indicator for Buildings

‘Smart Readiness Indicator for Buildings’ is a recent study, which was carried out by a consortium of VITO, Waide Strategic Efficiency, Ecofys and OFFIS. The study was ordered by the European Commission, Directorate-General for Energy. The preparatory study provides technical support to the Directorate-General for Energy of the European Commission in order to feed into the negotiations and decision process regarding potentially setting up a Smart Readiness Indicator for Buildings. Such a ‘Smart Readiness Indicator’ (SRI) can give recognition for smart building technologies and functionalities, which enhance the energy efficiency and
other pertinent performance characteristics of the building stock. The final report of the ‘Smart Readiness Indicator for Buildings’ study was released in August 2018.

The main objective of the study was to develop a harmonized SRI calculation methodology based on a multi-criteria assessment. The proposed SRI methodology is a qualitative labelling scheme. The SRI assessment procedure is based on a catalogue of the smart ready services, which are present in a building and an evaluation of the functionalities they can offer for occupants. Each of the services can be implemented with various degrees of “smartness” (referred to as “functionality levels”). The building services cover multiple domains (e.g. heating, lighting, electric vehicle charging, etc.) and can also result in various impacts (energy savings, comfort improvements, flexibility towards the energy grid, etc.). The multitude of domains and impact categories results a multi-criteria assessment method, which is proposed for calculating the smart readiness indicator for buildings (Verbeke, et al., 2018).

Figure 3: Overview of the SRI methodological framework
In the study a catalogue of smart ready services is developed, including 112 services. In the catalogue, services are structured within 10 domains:

1. Heating
2. Cooling
3. Domestic hot water
4. Controlled ventilation
5. Lighting
6. Dynamic building envelope
7. On-site renewable energy generation
8. Demand Side management
9. Electric vehicle charging
10. Monitoring and control

For some of the services listed in the full-service catalogue, relevant standards and methodological frameworks are currently lacking, therefore a reduced set of 52 actionable smart ready services can be used currently. For each of these services several functionality levels are defined. A higher functionality level means “smarter” implementation of the service, which generally provides more beneficial impacts to building users or to the grid compared to services implemented at a lower functionality level. The number of functionality levels varies from service to service, the maximum level can be as low as 2 or as high as 5. The functionality levels are expressed as ordinal numbers (level 0, level 1, level 2, etc.), implying that ranks cannot be readily compared quantitatively from one service to another. The multitude of domains and impact categories results in a multi-criteria assessment method. A smart ready service can provide several impacts to the users and to the energy grid. In the study, eight impact categories have been considered:

1. Energy savings on site
   This impact category refers to the impacts of the smart ready services on energy saving capabilities. It is not the whole energy performance of buildings that is considered, but only the contribution made to this by smart ready technologies, e.g. energy savings resulting from better control of room temperature settings.

2. Flexibility for grid and storage
   This impact category refers to the impacts of services on the energy flexibility potential of the building.

3. Self-generation
   This impact category refers to the impacts of services on the amount and share of renewable energy generation by on-site assets and the control of self-consumption or storage of generated energy.

4. Comfort
   This impact category refers to the impacts of services on occupants comfort. Comfort refers to conscious and unconscious perception of the physical environment, including thermal comfort, acoustic comfort and visual performance (e.g. provision of sufficient lighting levels without glare).

5. Convenience
This impact category refers to the impacts of services on convenience for occupants, i.e. the extent to which services “make the life easier” for the occupant, e.g. by requiring fewer manual interactions to control technical building systems.

6. **Well-being and health**
   This impact category refers to the impacts of services on the well-being and health of occupants. For instance, smarter controls can deliver an improved indoor air quality compared to traditional controls, thus raising occupants’ well-being, with a commensurate impact on their health.

7. **Maintenance and fault prediction, detection and diagnosis**
   Automated fault detection and diagnosis has the potential to significantly improve maintenance and operation of technical building systems. It also has potential impacts on the energy performance of the technical building systems by detecting and diagnosing inefficient operation.

8. **Information to occupants**
   This impact category refers to the impacts of services on the provision of information on building operation to occupants.

### 5.3 The ACE Policy Position on the Smart Readiness Indicator

The ACE welcomes revised EPBD approach to include control systems in the regulation of technical building systems and to propose a framework to better target the performance of control systems. The ACE also commends the Commission’s approach to catalogue the control capabilities of system types supplying each energy end use, in the context of the rapid growth of digital automation technology.

The 2018 revision of the EPBD states that automation promises better indoor comfort and air quality at lower energy use and carbon emissions. While automation has many advantages, there is ample evidence that control systems are a major factor in the energy performance gap. The ACE finds it concerning that the assessment carried out by the SRI study to quantify the potential impact of SRIs appears to assume that the system capabilities listed are all enabled and fully operational, which have been shown by building performance evaluations rarely to be the case.

If smartness is regarded by the EPBD as a panacea for achieving nearly zero energy buildings offering better indoor environmental quality, in practice this often happens at the detriment of investment in simple passive architectural measures. Higher than expected energy consumption in buildings is often attributed to the growing complexity of technical systems. Better regulation is needed to ensure that the construction sector adequately plans to eliminate the risks associated with automation and complexity in building systems.

The ACE supports the detailed review of smart capabilities and recommends that in this next phase of the SRI study, any proposed rating system shall fully recognise the risks alongside the benefits of increased automation in buildings.

**Rewarding complexity**

According to the current proposals the SRI rating given for any technical system capability is based on its level of automation, which in practice directly relates to its level of complexity. The current proposals for SRI therefore reward complexity without strengthening much needed mechanisms to address its risks. This is a major challenge to the credibility of the SRI and could further undermine the reputation of the EPBD. ACE
urges the Commission to find ways to safeguard investment in construction and renovations from the potential mis-selling of systems and services via SRI ratings.

The absence of a regulatory requirement to predict and validate energy performance in use have left the construction sector without the checks and balances to make provisions for realistic systems design, specification, installation and commissioning. The result is that the mechanical and electrical (M&E) construction package is already considered to be of the highest risk in building contracts. This translates to building end users and operators being all too often left with technical systems that are not sufficiently integrated into the overall design of a building, that are absent or not working as envisaged, which have serious consequences for energy consumption, indoor environmental quality and occupant well-being.

The EPBD states that the SRI “should give confidence to occupants about the actual savings of those new enhanced-functionalities”. To avoid the SRI rewarding ‘complexity without merit’, ACE maintains that the framework needs to create credible incentives for the automation sector to address the additional burdens and barriers affecting the professional design integration, installation, commissioning, operation and maintenance of automated technical systems and controls.

**Validation of performance – quality assurance**

The most notable of such barriers is the lack of market incentives for the design integration and commissioning of technical systems and their controls. The validation of performance is assumed to be an essential component of commissioning and handover, but due to the complexity of the process and fragmentation of responsibilities it rarely takes place in full and in practice, most control systems encounter problems from the start.

Key to any quality assurance framework for building systems and controls is the reconciliation of readings from sensors, meters and submeters with on-site, as well as remote access BMS logs of such data. Without such early validation of their capability in use, building systems cannot be reliably managed and incur exponential maintenance costs during their use cycle.

Such reconciliation is not only the cornerstone of benchmarking, diagnostics and occupant engagement but is the key enabler of cost-effective energy performance contracting. In the 2018 revision of the EPBD, energy performance contracting is referred to as a proven mechanism for achieving significant improvements of energy performance in-use. Moreover, benchmarking, logging and communication of performance data for system optimization and user engagement, as set out in Article 14/15 para 4b, can only be accomplished reliably once such a reconciliation has taken place.

By incorporating the ‘reconciliation’ of readings instead of just commenting on the theoretical capabilities of systems, the SRI ratings have the potential to become the much-needed quality assurance scheme for the design and commissioning of building systems and their controls. The SRIs, covering the controls of all technical systems in a building, should be rating their ‘reconciled’ or ‘validated’ performance to ensure that the energy and carbon savings, amounting to annual investment worth billions of euros, are realised in the EU.

The ACE argues that current proposals to base the third (long term) use of the SRI on measured data, along with the reconciliation process, must be brought forward and integrated into every level of the SRI rating scheme.

**Complexity of the SRI evaluation**
The SRI currently evaluates delivered services in 11 domains, assigned achievement levels of 0-4 then weighted by criteria A-H (services, feasibility, information etc.) using a points system (0-100), after which these are weighted by impacts to arrive at a single A-G rating. ACE is concerned that the number of assessments could lead to highly subjective and variable results. Even the streamlined proposals include 52 services to assess in less than a day, raising concerns about the quality achievable for such a complex evaluation in such a short time. In addition, ACE believes that a single final rating would not disclose any useful information relating to the capabilities of systems to manage themselves and interact with occupants or the grid.

While the case study described by the SRI report tested the time required to ‘score’ a building, it did not take into account the time required to source documentation, including control strategy and as-built information on systems. In our experience this is one of the most time-consuming tasks when undertaking ‘reconciliation’.

ACE argues that achieving the purposes of the SRI does not necessitate automation. However, it does require correct feedback from sensors and meters, as well as oversight of these readings, to ensure that the level of performance envisaged is achieved.

The impact categories include energy savings on-site, flexibility for the energy grid and storage, self-generation of energy, comfort, convenience, well-being and health, maintenance and fault prediction, and information provided to the occupant. KPIs for these could include daily and annualised energy end use consumption, energy balance, and indoor environmental quality, as defined by the EU LEVELs programme. Any faults and shortcomings in the systems would manifest as anomalies in these indicators and if these are presented in an accessible and benchmarkable format, they would prompt questions and actions on behalf of the owner/occupant/building operator.

ACE values the detailed mapping of the currently available automation features to achieve improved indoor environmental quality with less and decarbonised use of energy. However, ACE recommends that the SRI rates the validation and communication of key performance indicators for each impact category rather than the presence of system properties that enable these. The purpose of SRIs is not to prescribe how to achieve these indicators but to ensure that they are achieved, so that the automation market is incentivised to innovate.

As the technologies are likely to continue to evolve rapidly, the current approach poses a high risk of SRI obsolescence. On the other hand, incentivising feedback on the KPIs would be a major step towards closing the energy performance gap and improving the credibility of the EPBD. In this way the catalogue of services and functionalities would become live guidance and, in some cases, EN standards.

**Uptake**

There are challenges and opportunities identified by the extensive work undertaken as part of the development of SRIs. The direct beneficiaries of SRIs are the automation industry, electric mobility sector and energy providers. However, the costs of smart systems and their evaluation are met by building owners and end users. To these investors, the only direct benefit is the quality assurance potentially granted by the SRI for low energy use, greater comfort and ease of maintenance.

ACE recommends that a detailed evaluation of the expected benefits of SRIs is carried out and that easy entry points are identified for each stakeholder. Any guidance for owners, valuators, occupants, designers, contractors and facilities managers should be based on the feedback from such evaluation.
The current proposals to rate the theoretical capabilities of technical systems are likely to be recognized by the market as a box ticking exercise rather than an actual guarantee of systems being installed and enabled to specification. If higher ratings are linked to complexity as currently proposed the SRIs risk developing an inverse quality assurance: the higher the ratings the greater the risk of underperformance.

ACE believes that the focus on validation of KPI readings rather than the theoretical capabilities of systems is the logical way forward to address the concerns raised at the stakeholder meetings.

Such a common sense approach would remove much of the complexity of the evaluation and solve the problem of the SRIs rewarding complexity. It would immediately strengthen the process of enhanced commissioning and enable performance contracting, the two areas that are recognised as highly effective by the current regulatory framework but lacking incentives. It would help the transition towards replacing annual on-site inspections with remote ones and pave the way for much more cost-effective remote inspections.

Such a scheme would offer easy entry points for less technical stakeholders and provide immediately to building owners and occupants – value for investment as well as feedback on performance. It would present obvious and simple links to the currently evolving Building Passports scheme and lead to a more holistic understanding of what the smartness of a building means.
6 Teaching the value of architecture for building performance

In this section the project partners tried to identify the degree to which the value of ‘good’ architecture and its influence on building performance is taught in architecture schools in their countries. Hence the following sub-chapters focus on Hungary, Italy and Spain. Additionally, an online survey was run by the Architects’ Council of Europe (ACE) in cooperation with the EAAE – the European Association for Architectural Education in order to provide a European overview.

6.1 A European Overview

This report set out by defining various sets of criteria, which are influenced by ‘good’ architecture. Although they have differing unit/ currencies in which to measure the value of good architecture, it is nevertheless evident that good architecture has the potential to raise the value of buildings in relation to these seven areas. The criteria have been used as a basis for an online survey amongst European architecture faculties and departments. The aim was to investigate to which extent these aspects of ‘good’ architecture are taught to students and researched. The following Architecture Schools have participated in the survey and are summarised in figure below. The exact courses are compiled in a table in Appendix 1.

Figure 4: Participating European Architecture Schools in the survey
Bulgaria
- UACEG - University of Architecture, Civil Engineering and Geodesy (https://www.uacg.bg/?l=2)

Hungary
- Budapest University of Technology and Economics (http://www.bme.hu/EPK)

Italia
- Universita’ degli studi di Firenze (https://www.unifi.it/)

Netherlands
- Delft University of Technology (https://www.tudelft.nl/en/)

Portugal
- Évora University (https://www.uevora.pt/)
- University of Coimbra (http://www.uc.pt/en)

Slovenia
- University of Ljubljana (https://www.uni-lj.si/eng/)

Spain
- Politècnica UCAM, Murcia (https://www.ucam.edu/)
- Universitat Politècnica de València - Escuela Tècnica Superior de Arquitectura de València (http://www.upv.es/entidades/ETSA/)
- Universitat Politècnica de Catalunya - Escola Tècnica Superior d’Arquitectura del Vallès (https://etsav.upc.edu/ca)
- Universitat Politècnica de Catalunya - Escola Tècnica Superior d’Arquitectura de Barcelona (https://etsab.upc.edu/ca)
- Universidad Politécnica de Madrid (http://www.upm.es/)
- Universidad de Granada – Escuela Técnica Superior de Arquitectura de Granada (http://etsag.ugr.es/)
- Universidad de Sevilla - Escuela Técnica Superior de Arquitectura (http://etsa.us.es/)

United Kingdom
- University of Sheffield (https://www.sheffield.ac.uk/)
- Oxford Brookes University (https://www.brookes.ac.uk/)
- University of Reading (http://www.reading.ac.uk/)
The Table below depicts the answers for each participating country for the main seven areas. The economic value is most taught in the United Kingdom. The University of Reading is currently conducting a Value Study for the Architects’ Council of Europe, which might be related to the question of the economic high value of architects and the other high values found in the responses of the UK. The Netherlands replied with 100% to almost all areas, which only speaks about the quality of teaching at the participating University of Delft and the role of architects in the country. In Bulgaria and Hungary the value of architects appears to be not well perceived. In Italy the cultural and well-being factors are the most perceived, whereas in Portugal the cultural and heritage value an architect brings seems to be vital. The well-being and heritage areas are also the most taught ones in Slovenia, while in Spain everything seems to be taught a bit.

**Table 3. Taught Criteria Areas of good architecture per country**

<table>
<thead>
<tr>
<th>Country</th>
<th>ECONOMIC</th>
<th>ECOLOGICAL</th>
<th>SOCIAL</th>
<th>FUNCTIONAL</th>
<th>CULTURAL</th>
<th>WELL-BEING</th>
<th>HERITAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgaria</td>
<td>0%</td>
<td>25%</td>
<td>30%</td>
<td>43%</td>
<td>10%</td>
<td>56%</td>
<td>50%</td>
</tr>
<tr>
<td>Hungary</td>
<td>20%</td>
<td>17%</td>
<td>20%</td>
<td>29%</td>
<td>40%</td>
<td>38%</td>
<td>40%</td>
</tr>
<tr>
<td>Italy</td>
<td>40%</td>
<td>25%</td>
<td>30%</td>
<td>21%</td>
<td>60%</td>
<td>75%</td>
<td>40%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>40%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>88%</td>
<td>100%</td>
</tr>
<tr>
<td>Portugal</td>
<td>24%</td>
<td>30%</td>
<td>34%</td>
<td>46%</td>
<td>96%</td>
<td>53%</td>
<td>92%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>40%</td>
<td>25%</td>
<td>20%</td>
<td>14%</td>
<td>40%</td>
<td>75%</td>
<td>60%</td>
</tr>
<tr>
<td>Spain</td>
<td>15%</td>
<td>27%</td>
<td>29%</td>
<td>27%</td>
<td>23%</td>
<td>36%</td>
<td>34%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>73%</td>
<td>97%</td>
<td>97%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

When looking at the most taught area overall in the survey results it is the heritage criteria. This is followed by well-being and cultural on second and third place. The economic value is the least taught value at the participating EU architecture schools. This could relate back to the comparable low salaries of architects as well. Assuming that if an architect knew about her/his economic value the salaries would increase. For an up-dated survey of EU wide architecture salaries the ACE Sector Study could be consulted under: [https://www.ace-cae.eu/?id=999](https://www.ace-cae.eu/?id=999)
The figure below displays the ranking of the individual criteria taught at the participating universities. The colouring provides an insight to which area the criteria belong to in order to ease the understanding. It is interesting to see the functional criteria so low, as usually architectural design is strongly linked to functions, as the famous quote of the 19th century architect Louis Sullivan. This figure is just intended to provide an overview of all criteria. The criteria per area can be found in the following figures thereafter.

Figure 5: The ranking of the seven main areas of ‘good’ architecture taught at EU Architecture Schools
Figure 6: The ranking of the taught criteria

Figure 7: The ranking of the Heritage criteria
Figure 8: The ranking of the Well-being criteria

Figure 9: The ranking of the Cultural criteria
Figure 10: The ranking of the Functional criteria

- Improve accessibility
- Enhance functionality and fit for purpose
- Improve daylight access.
- Increase the urban quality experience
- Use building mass to improve thermal comfort
- Enhance urban strategies for public transport
- Improve the flexibility and adaptability of layouts for a longer life-cycle
- Improve buildings for a user’s whole life cycle
- Improve safety for occupants and construction workers (prevent fire, minimize earthquake/flood damages)
- Consider the floor to ceiling height in order to improve the user’s experience
- Improve navigation through spaces
- Increase alternatives to reduce car dependency
- Improve urban strategies for active transport
- Enhance building legibility (the degree where the use of the building could be easily understood)
Figure 11: The ranking of the Social criteria

- create liveable places
- support communities' identities and create a sense of belonging
- increase occupant satisfaction by Post Occupancy Evaluation
- provide a social return of investment
- provide strategies to prevent deprivation
- addresses active ageing design for elderly
- be socially sustainable
- inclusive spaces that support diversity
- provide strategies to prevent crime
- enhance visual appearance of the build environment
- creating a visual value for the community
Figure 12: The ranking of the Ecological criteria

Figure 13: The ranking of the Economic criteria
Following are some quotes from the free text entries of the survey on the question why a certain aspect was not taught at the respective university.

**Economic Value**

**United Kingdom**

‘The main emphasis is on designing architecture that is generally benign to the user - there is not an emphasis on profit/capitalism or productivity as such.’

**Portugal**

‘Being "design-centred" and "free of constraints" like costs, there is no subject on costs, energy efficiency nor indoor air quality.’

‘Economic value is more present at the urbanism level (taught in the 5th year of the course) and not as much at the architectural level, more focused in the artistic, historical and technical qualities of architecture.’

**Spain**

‘Economy is completely obviated.’

‘The economic issues are not present in mandatory studies of our school’

**Ecological Value**

**Spain**

‘The school is very focused on artistic ant technical issues more than ecological values.’

‘Most courses focus on architecture as something that should create admiration and surprise.’

**Social Value**

**United Kingdom**

‘Social Return on Investment is a very poorly defined concept and therefore hard to teach. Designing out crime is not taught as such - we teach good design, which is hopefully a way to avoid crime also through promoting wellbeing, health, reducing fuel poverty and increasing happiness. We also address financial inequality by teaching community design projects where we aim to empower local communities.’

**Portugal**

‘Lack of awareness’

**Functional Value**

**Portugal**
'Lack of validation of the whole effect of options. Better daylight can also mean worst working conditions (glare, excess heat, heat loss, fuel poverty, ...) but that would require a quantification that is often forgotten.'

'These are assumptions that architecture can solve everything.'

**Well-being Value**

*Portugal*

'Technical topics kept away, perceived as limitations to creativity.'

Having gained an overview of other European Architecture Schools we will now move on into detail to the consortium partners university and examine their courses offered on the value of architecture in detail.

### 6.2 HUNGARY (Budapest)

The Budapest University of Technology and Economics has an Architecture Faculty. Within the Architecture Faculty the Department of Building Energetics and Building Service teaches building performance in the following subjects:

**Building Physics (in Hungarian and English):**
Course: Compulsory, 2 hours of lectures per week, 2 credit points  
Topics:
- One dimensional steady state heat transfer of composite slabs
- Linear heat transmission
- Psychometrics and moisture transfer

**Building Service (in Hungarian and English) 1:**
Course: Compulsory, 2 hours of lectures per week, 2 credit points  
Topics:
- Integrated design approach
- Thermal Comfort
- Indoor air quality
- Daylighting, artificial lighting
- Smart and nZEB buildings
- Smart controlling in hydraulic systems
- Building automation

**Building Service (in Hungarian and English) 2:**
Course: Compulsory, 2 hours of lectures per week, 2 credit points  
Topics:
- Heat loss calculation
- Energy consumption
• Heating systems
• Ventilation systems, air change rate
• Air conditioning systems

**Building Energetics (in Hungarian):**
Course: Compulsory within a few optional, 2 hours of lectures and 2 hours of practice per week, 4 credit points

Topics:
• Thermal comfort, indoor air quality, building physics
• Building energy calculations based on the Hungarian regulation
• Calculation of the building certificate
• Energy audit of buildings
• Nzeb and smart buildings

---

**6.3 SPAIN (Valencia Region)**

**Degree in Architecture - ETSAV – UPV**


The bachelor's Degree in the Fundamentals of Architecture, together with the master’s degree in Architecture, replaces the old degree in architecture. These aim to train future professionals to be able to create architectural plans that satisfy the users’ aesthetic, technical and other requirements, always respecting the limits imposed by cost factors and building regulations.

Compulsory subjects are divided into six main blocks: preparation subjects, history and theory of art and architecture, construction and building materials, structures, urban planning and architectural projects, upon which relays, according to this study planning, the value of architecture.

**Degree in Architecture - Universitat de Alicante (UA)**

[https://eps.ua.es/es/arquitectura/](https://eps.ua.es/es/arquitectura/)

The overall purpose of the studies of the degree in architecture is to prepare versatile, flexible, creative and competitive professionals with ability to conceive and design architectural projects, collaborate with professionals in technology related and technological decisions in accordance with criteria of cost, quality, safety, time and respect for the principles of the profession. Its general aims are, among others, to get: the ability to create architectural projects that meet both aesthetic and technical requirements; working knowledge of architectural history and theories, along with related arts, technology and human sciences; and an understanding of fine arts as an influence on the quality of architectural conception.

The degree course consists of 330 ECTS credits distributed over 6 years (11 semesters), bearing in mind that the last semester is given over to the Final Project. The course programme has been structured around three main areas which relay on a traditional point of view for architectural value: a Preparatory Block, where 36 ECTS are dedicated to Graphic Expression matters (including aesthetics or visual integration as architecture values – cultural, heritage values); a Technical Block, where 42 ECTS are dedicated to Construction matters (including daylighting or shadowing systems, durability or resilience – functional, heritage values) and 18 ECTS to Installations matters (including notions of conditioning systems, IAQ and artificial lightning –...
functional, health values); and a Project Block, where 36 ECTS are dedicated to Composition matters (including historic value or heritage – cultural, heritage values) and 72 ECTS are dedicated to Projecting matters (including biophilia, floor to floor height, adaptability, views, flexibility, etc… - functional, social values).

It seems not to pay attention to Building Performance, Occupant satisfaction satisfaction (ecological values) or Real Estate/ property valuation (economical values). Degree in Building Engineering - Universitat Jaume I Castellon (UJI)


The value of architecture is in this study plan very technically oriented (stability, durability, resilience – heritage values), and it offers just one elective subject on the last year of the degree (fourth) about energy performance (6 ECTS – ecological values). It focuses on constructive solutions, building materials and facilities selection from a sustainable point of view. Passive and active strategies are discussed to achieve the reduction of CO₂ emissions produced by buildings. Design, energy efficiency and sustainability are discussed. It complements the courses about facilities, construction and materials in order to achieve an ecological approach to get more sustainable building environments.

MASTERS IN REHABILITATION AND URBAN REGENERATION (RERU) – IVE

http://www.five.es/master-reru/

Since building performance (mostly ecological and health values) was not perceived as deepened enough in the general public studies of architecture in the Valencia region, IVE created a specific master’s degree, focused on building performance and applying a methodology, which involves all stakeholders on the building performance achievement process: from policy makers, technologies providers, architects, private companies to the public sector.

Training action is aimed primarily at architects, technical architects, building engineers and other engineers related to the building sector and urban planning.

Teaching Methodology: The teaching is taught through theoretical and practical classes, lectures, workshops, visits to buildings and urban environments of interest, as well as through the management of research. In its dual theoretical and practical nature, teaching includes explanations of topics, comments of specialized lectures, case studies, practical exercises and simulations.

This degree will enable the student to manage and resolve comprehensive urban regeneration processes, such as rehabilitation of collective housing buildings built in the decades between the 40s and 80s.

The purpose is to facilitate the adaptation of related technical content to the construction industry, working for both the public and the private sector, administrative and technical requirements of the processes of urban regeneration and rehabilitation of buildings of collective housing, to varying degrees and levels of complexity. At the end the student can analyse buildings, raise the most appropriate intervention for each case to solve the problem and manage the rehabilitation process. Additionally, students will be able to evaluate the different solutions to find one that offers an adequate level of security being economically competitive. At the urban level, it is based on the conviction that a project cannot be implemented without urban regeneration while taking economic, administrative, social and urban impact that this implies from a
political and ethical perspective. Furthermore, any initiative that involves many actors, especially the administration must equip itself with tools and methodologies that will work in this master. The goal is to combine theoretical training with calculation and resolution of practical cases that allow students to finish the course with the criteria and resources to face real problems. It must equip itself with tools and methodologies that will work in this master.

This is achieved through subjects such as (among others): Management building rehabilitation (2.5 ECTS), Building inspection and diagnosis (4.5 ECTS), Energy analysis of buildings (4 ECTS), Improved sanitation, acoustic and buildings accessibility (6 ECTS), Introduction to rehabilitation of buildings and urban regeneration (1 ECTS), Improving the energy efficiency of buildings collective housing (5 ECTS), or Participatory rehabilitation of building loans (0.5 ECTS).

6.4 ITALY (UNIBO - Alma Mater Studiorum - University of Bologna)

Alma Mater Studiorum, University of Bologna provides, in the Cesena Campus, The Single Cycle Degree in Architecture (Combined Bachelor and Master - 300/360 ECTS - https://corsi.unibo.it/singlecycle/architettura) that aims to form professional figures with specific skills in architectural and urban design, in urban and landscape design, in technological, structural and environmental design, in architectural restoration, in the conservation and enhancement of architectural heritage and in interior design. The Master’s Degree in Architecture offers an educational path for the training of new professional figures able to measure themselves against the complexity of building production and the transformations of the contemporary city both at a local and at a territorial level. Within the 5-year teaching period, students attend to specific courses concerning architectural value and building performance:

70087 - DETAIL DESIGN FOR ENERGY EFFICIENCY

The learning path includes the analysis of building elements and technologies with reference to work execution issues and from the perspective of process sustainability. The issues of environmental protection and quality of living are increasing their importance in contemporary design. Specific interrelations between the changing of users’ behavior and the evolution of new concepts of living are outlined at brief level, design approach and execution and management level: a very close connection links technological innovation to environment and living conception, therefore an integrated approach is essential.

42969 - ILLUMINATION ENGINEERING AND ACOUSTICS

-After the course, the student will know the fundamentals of lighting and applied acoustics necessary to properly design a building. In particular, the student will be able to properly design a building envelope having the necessary acoustic and lighting requirements.

82662 - ENERGY EFFICIENT BUILDING DESIGN AND PERFORMANCE ASSESSMENT
This course provides the skills related to the energy efficiency of buildings, the application of renewable energy technologies (solar, geothermal, ...) integrated in the building and knowledge of systems and their performances in terms of energy efficiency. In the design process, congruence between design choices, technological systems and solutions aimed at defining high performance integrated solutions is to be clear. This course embeds different modules for Sustainable Design Technologies, Energy performance evaluation, Sustainable Design, Energy Savings Design.

In the Bologna Campus takes place the Single Cycle Master’s Degree in Architecture and Building Engineering (Combined Bachelor and Master - 300/360 ECTS - https://corsi.unibo.it/singlecycle/ArchitectureBuildingEngineering) that aims to form professional figures linking engineering and architecture, strongly oriented towards the design and control of construction and production processes. One of the main goals of this course is to integrate the traditional methods and techniques of engineering focusing on the design of structural components and building systems, the production and use of materials, environmental control of architectural and urban spaces; as well as those of architectural traditions, concerning design as a synthesis of form, function and construction, the typological, morphological and linguistic features of architectural elements, restoration and redevelopment of buildings and city landscapes. Within the 5-year teaching period, students attend to specific courses concerning architectural value and building performance:

73710 - BUILDING PHYSICS AND INDOOR ENVIRONMENT

The students will learn the principles of classical Thermodynamics and their extension to open systems. They will learn how to deal with simple thermodynamic systems. The students will be able to calculate the properties of atmospheric air, to work with its transformations and to apply them to HVAC systems. The students will learn the basic mechanisms of Heat Transfer: conduction, convection and radiation. They will be able to deal with water vapor condensation in building structures at a basic level. Focusing on engineering applications, they will be able to handle in the correct way practical problems of heat transfer and energy conversion.

73727 - APPLIED ACOUSTIC AND LIGHTING

The aim of the course is to give to students the essential tools to work in the fields of applied acoustics and lighting, basing on physical principles and considering the connections with other technical and architectural disciplines. The course will cover sound propagation outdoors and noise control, acoustical design of buildings; design of music and conference halls, artificial and natural lighting of interiors, artificial lighting of roads. The course includes a basic knowledge of measurement equipment and techniques and Italian and international technical standards.

77867 - SUSTAINABLE DESIGN
(https://www.unibo.it/it/didattica/insegnamenti/insegnamento/2015/400470)

The aim of this course is to teach students how to apply performance verification tools through the use of dedicated software, formulate design solutions that meet the requirements of sustainability of products and processes in construction. In line with the main topics of research in the field of architectural and energy qualification in urban and peri-urban areas, the program is essentially aimed
at reinterpreting - in an ecological and sustainable way - existing urban settlement sectors with the aim of achieving near zero energy buildings (nZEBs buildings). This reinterpretation will be developed through design explorations used as a tool to control the environmental quality of the built system. This method is accompanied by the use of systems to verify the thermal behavior of buildings through specific lessons on thermal transmittance of envelope, renewable energy in accordance to recent national regulations and energy certification of buildings.

79585 - TECHNICAL INSTALLATIONS T

(https://www.unibo.it/it/didattica/insegnamenti/insegnamento/2017/404549)


In the Ravenna Campus takes place the Second Cycle Master’s Degree in Engineering of Building Process and Systems (Second cycle degree/ two-year Master - 120 ECTS - https://corsi.unibo.it/2cycle/EngineeringProcessesSystems/course-structure-diagram) that aims to train highly specialized professionals, with the necessary skills to carry out and direct the planning, coordination and control activities of historical building rehabilitation processes, occupying the positions characterized by these tasks both within companies in the construction and related sectors, and in the Public Administration, or offering them such services as a free professional activity. For this purpose, this master’s degree is divided into two curricula:

- Management Of The Building Process In The Recovery Of Historical Buildings: this curriculum teaches the basics on the technical, legal-economic and organizational-managerial conditions necessary for the optimization and control of the building processes of transformation and rehabilitation of the built environment

- Historic Buildings Rehabilitation: this curriculum improves the critical analysis of the characteristics of the historical heritage, the diagnosis of its conservation conditions and the definition of the methods for the consolidation and restoration of the artefacts, applying effective solutions and techniques compatible with the protection of its characteristics.

For both curricula, within the 2-year teaching period, students attend to specific courses concerning architectural value and building performance:

77818 - FUNDAMENTALS OF PERFORMANCE DESIGN M


After completing the course, the student has acquired the theoretical references and operating methodologies appropriate to organize the design process of a building project. The student will be able to perform an analysis of the needs to comply with, and to determine them using the Performance Based Building Design (PBBD) approach. In particular, at the end of the course the student is able to formulate the expected performances of an intervention of rehabilitation, and the suitable metrics for their assessment.

78337 - TECHNOLOGIES FOR EXISTING BUILDING RENOVATION M
At the end of the course, the pupil is able to deal with and develop, up to the detail of some of its parts, a project to preserve / modify an existing building artifact, by recognizing the forms of degradation and functional deficiency, identifying the economic viability and effective and adequate techniques for rehabilitation and improvement of energy performances.

### 6.5 SLOVENIA (University of Ljubljana)

Building performance in various senses is lectured in several faculties of University of Ljubljana. The last is in the focus of this report. The main topics are at the Faculty of architecture. In addition to the University of Ljubljana, some classes are given at University of Maribor, Faculties of Civil and Mechanical engineering and Faculty of Energetics.

**UL FA - University of Ljubljana, Faculty for Architecture**

It is generally considered one of the best Central European schools of architecture. Confirmation of its quality comes from numerous successful students and graduates, often achieving enviable results domestically and abroad. Graduates are known for their general and professionally profiled knowledge and systematic project approach enabling successful employment in various fields of artistic and architectural endeavours.

**Study programmes offered at the FA relevant for this report:**
- Single masters study programme Architecture (5 years)
- Doctoral Programme in Architecture (3 years)

There is no dedicated program for energy efficiency of the buildings, but several courses cover these specific topics, such as:
- Building Physics
- Utility Technologies
- Light in architecture
- Ecological building principles
- Energy and environmental assessment of the building

Subjects relevant for this report are UL taught also in faculties mentioned below.

**Faculty for Mechanical Engineering:**
- Renewable energy sources

**Faculty of Civil and Geodetic Engineering:**
- Constructional Building Physics
- Daylight
- Efficient Energy Use
- Living Environment
7  Best practice examples

This chapter provides a few best practice examples of residential renovation projects with a high involvement of architects. They could be seen as a proof of the value they bring to the built result.

7.1  Case 1: Rochestown House

Rochestown House comprises two separate blocks built in the 1960s, as well as a small terrace of single storey houses in the walled garden of Somerton House in Sallynoggin (Dublin). This project is part of ‘The 20 Architectural Projects against Climate Change’ (The Architects’ Council of Europe (ACE), 2018). The project in Sallynoggin, Ireland was realised by the architect Dún Laoghaire, in 2016. It is EnerPHit certified and has received the HRIAI Award for Sustainable Project (2017)

The location provides a much loved and tranquil setting for elderly residents that is close to shops, bus services and open space. Because of these advantages, it was decided to run a programme of re-using and re-adapting the existing buildings. The originally cramped, cold and damp social housing block has been completely transformed thanks to a deep energy retrofit inspired by passive house principles. In addition, a process of densification is taking place with additional units currently under construction. The local community is strengthened with the introduction of additional residents, which helps to sustain on site services. The project also maximises independent living options within the complex for residents as they age, through variation in housing types.

The site was regenerated by omitting all existing bedsits; upgrading fabric and building performance; enhancing the sense of community through careful design; providing units that could adapt with the tenants needs; and providing units that would be a viable option for existing tenants. It is a two-storey building with 34 units, mainly bedsits that have been remodeled. It also provides nurse stations, communal laundry facilities and a communal room. An additional floor was added to provide one bed-units suitable for the elderly. The next phase of the project will provide an additional 14 passive house dwellings to the site.

The building has undergone a deep retrofit to achieve the EnerPHit standard – the passive house certification standard for existing buildings. Despite being highly designed for energy efficiency, the architectural language of the project responds quietly to the context of the walled garden, where new elements are expressed in simple forms and built with brick and timber to create warm comforting textures.
7.2 Case 2: BUILDSMART Site Bilbao


The demonstration building in the context of the European Project BUILDSMART is a three-block residential building located in the Portugalete municipality in Greater Bilbao, Spain, and is developed by the Basque Government’s Department of Housing, Public Works and Transport. The implemented technologies had to be energy-efficient in order to achieve the target value but at the same time low-cost, because the developer couldn’t afford expensive technology. The social scope of the project is also important as it is oriented towards social housing. Therefore, the building will be low-cost in order to be affordable for tenants of low-medium income.

Impact:

This residential building serves for social housing oriented to low-income residents. It has been designed as a passive solar house with a targeted annual energy use of 42 kWh per m². The design of the building aimed to minimise its environmental impact by using materials with low embodied energy and low environmental toxicity wherever possible.

Architectural value for occupants:

- Heritage: New aesthetics
- Economic: lower energy costs
- Environmental
• Health: indoor comfort

Measures:

Energy:

• Retrofitting the building envelope: Parietodynamic wall, integrated with the building ventilation system, to maximise the energy storage in the façade; An insulating painting with nanotechnology, which is designed to insulate and waterproof the walls; Green roofs, which provide insulation in winter and prevent overheating in summer

ICT:

• Building management system: An energy display screen was installed in each of the buildings, providing information on heating, lighting and electric energy consumption. This is a tool for communicating with the residents, making them aware of their energy consumption to help improve users’ behaviour.

More info:


7.3 Case 3: EU-GUGLE Site Sestao

https://smartcities-infosystem.eu/scis-projects/demo-sites/eu-gugle-site-sestao

Located 11 km from Bilbao, Sestao is a municipality with a strong post-industrial character. It has an area of 3.5 km2 where only 0.9 km2 are devoted to residential use and the rest is used for industrial purposes.

The demonstration district included in the EU-GUGLE project is located in the lower area of Sestao and is the most affected by the de-industrialisation process, with high unemployment rates. There is a mixture of local and immigrant populations with limited economic resources and a low academic level. The building stock consists of residential buildings, most of which have private owners, but there are a few public buildings. Most of them were built between 80 and 100 years ago in wood resulting in poorly ventilated interior rooms and no natural light distribution. The renovation area covers 24 509 m2 and is made up of 258 dwellings with 1300 inhabitants.
Impact:

Since most of the buildings in the demonstration are privately owned, energy-efficient refurbishment measures will not have a significant impact on rent prices. But, to carry out the rehabilitation work it was necessary for the public administration to assume ownership of some of the homes then, once they were renovated, these homes would be sold or leased to private parties with protection criteria of public housing. This does not just mean a change in ownership of dwellings but also a renewal and rejuvenation of the population living in the district.

Architectural value for occupants:

- Economic: Raise the value of the homes in terms of their market price and impact on the residents’ energy bills
- Social: rejuvenation of the population living in the district. The allocation of housing to protection criteria of publicly-owned buildings not only guarantees the arrival of new families, but also the possibility of elderly people and people with mobility problems getting secure housing in the area.

Measures:

Energy:

- Retrofitting the building envelope: Rehabilitation resulting in reduction of waste, costs and CO2 emissions, with the use of sustainable materials such as wood, plasterboard, prefabricated panels,
etc.; solar protection in hollows and façade; Reduction of envelope thermal transmittance; Windows replacement.

- Building services (HVAC and lighting): Planned rooms with natural light and airy spaces, achieving an improvement to the houses’ ventilation conditions
- Biomass boilers: Biomass centralised boilers for the production of hot water and heating (20 %)
- Thermal collectors: Renewable thermal energy through solar panels for hot water and space heating (80 %)
- Waste heat recovery: Lifts with excess energy recovery system

ICT:

- Building energy management system: Programmable thermostats for heating systems
- Automatic ignition/shutdown systems in the common areas of the building. Low consumption lamps or fluorescent tubes at points of long periods of operation (> 3 h)
- Use of bicycles promotion to facilitate space in buildings to save them.

Use of bicycles promotion: to facilitate space in buildings to save them.

More info:


http://eugugle.eu/pilot-cities/estao/

7.4 Case 4: ZENN Site Eibar


The Mogel neighbourhood in Eibar has been going through an integral renovation project since 2006. A lift installation and an energy-efficiency improvement to the residential buildings have been developed using diverse financing sources, including EU funding through the ZENN project.

Impact:

Retrofitting works have been performed in several stages in all of the buildings in the community, which has completely transformed the neighbourhood. The residents are pleased, feel more comfortable at home and their quality of life has increased.
Architectural value for occupants:

- Heritage: complete transformation of the neighbourhood
- Health: comfort and quality of life

Measures:

Apart from the lift installation, an energetic efficiency improvement of the residential buildings was proposed. This would be achieved primarily by improving the building cover as well as the installation of a system for sanitary hot water production by means of solar panels.

Energy:

- Retrofitting the building envelope
- Building services (HVAC and lighting)

Lessons learned:

An important success factor is that the residents have been kept well informed about the technical and economic aspects of the project throughout the whole process. The information was distributed at general assemblies with the neighbours, meetings with the presidents of the communities, meetings in the residential blocks and an information tent in the neighbourhood, as well as via mailing and press relations.

More info:

http://zenn-fp7.eu/demonstrationsites/mogelspain.4.3d71f8313d6a4ffc793240.html

7.5 Case 5: HAPPEN Site Castellón


Castellón de la Plana is the capital of one of the three provinces of the Valencian Region, with more than 170000 inhabitants, and 70 km far from Valencia. The pilot building is one of the 17 urban interventions expected within the city in the next few years, for a total of 2050 dwellings, owned mostly (98%) by the Regional Government, and is the target of a process of refurbishment carried out in close connection with local social associations.

Castellón is characterized by low CSI values for the winter (-0.07) and high values for the summer (1.22). This means that summer is more “severe” resulting in increased cooling needs compared to the heating demand.

The building is included in Castellón General Urban Planning qualified as urban ground and was built in 1979. The area is defined as high density block in the Old Town of Castellón. Its basement is destined to parking; the ground floor is destined to commercial uses. There are 36 dwellings.

The building has concrete structure composed by columns, beams and slabs with an underground floor used as garage. The brick finished façade has internal air chamber without insulation layer. On top of the building an accessible flat roof with exposed waterproofing layer is the fifth facade. The window frames are made in
aluminium with simple glazing system. There aren´t adjustable sun protection systems but shades located on every window. The heating and cooling systems are individual and no centralized, which means every neighbour has solved the problem on its own. There are no energy support systems (PV or Solar collector) on the roof. Sometimes the DHW generator is electric and others by gas. A/C units almost in every apartment.

The proposal of this building as a Happen pilot comes after a thorough analysis of its urban context qualities, the neighbourhood situation and the building typology itself. It appears to be a good opportunity to put in practice HAPPEN´s engagement and empowerment of target groups protocols (such as owners, inhabitants, building professionals). Technologically speaking the building systems haven´t been updated for a long time and, probably the owners don´t have economic resources to assume the costs of the renovation works so, financial solutions for supporting the market uptake of deep retrofitting principles could be exercised through this pilot.

The intervention to be developed into Santa Cruz de Tenerife building refurbishment attends almost the whole construction definition. The original building from 1979 was adequately emptied ten years ago in order to wait for the refurbishment that is currently being developed under HAPPEN criteria. The building will be renovated completely excepting the structure, which will be checked accordingly to the new requirements. The internal layout has been designed to ensure accessibility, flexibility and neighbourhood diversity. The building systems have been chosen to accomplish HAPPEN´s latest goal of reaching 60% of energy savings. To do so, the building counts with a Heat pump system for DHW and (HVAC), LED luminaires with presence control system, PV´s to feed the elevators movement. The MEP package has been engineered to reduce the energy consumption while guaranteeing the internal comfort in every apartment.

Envelope, Roof construction elements and Materials have been set out to reduce heat transfers and increase airtightness. Low emissive glazing combined with thermal breaking frames, insulated walls both externally and internally and slab insulation in specific locations are some of the measures taken to accomplish the NZEB goal. Regarding the urban implications of the building renovation, the materials used in the façade will be upcycled from the existing one, treated to reduce the heat due to radiation (heat island reduction). The roof will follow the same criteria, choosing a floor finish material with the highest albedo coefficient as possible. Other passive design strategies, like natural ventilation of common and private areas, have been implemented.
The decision-making process that shapes the building renovation is founded in the Optimal Solution protocol, which allows HAPPEN to choose the most adequate solution regarding costs and energy performance. Every element, from the underfloor insulation material to the roof construction system has been selected following the cost-performance optimal solution criteria.

7.6 Case 6: e2ReBuild, Munich

Lichtblau Architekten worked on an exemplary model in another significant EU funded project, E2ReBuild project, co-financed in the 7th FP (Figures 1 and 2).

In fact, E2Rebuild aims to promote and demonstrate advanced, cost-effective, energy-efficient retrofit strategies by creating added value for existing apartment buildings and encouraging a dynamic society. Moreover, it intends to establish and investigate sustainable renovation solutions that will reduce energy use and also promote an holistic industrialized process that will minimize technical and social disturbance for tenants, will facilitate energy-efficient operation and will encourage energy-efficient behaviour. The partners of this project are from universities providing research activities, demonstration owners providing demonstration projects, architects and consultants, providing practical experience and manufacturers providing practical experience and knowledge and producing demonstration projects.

All the interventions such as building envelopes, life cycle, urbanism and architecture were part of a holistic industrialized retrofitting approach.

In a building block of 1958, a holistic renovation for an ideal life cycle was performed. A prefabricated wood envelope was designed. In order to build in a sustainable way, first there is the need to adopt a sustainable attitude. Working simple and flexible is what sustainability means. The necessity in order to achieve the best result is to combine all these aspects. Furthermore, the only way to reach the best economic result is to learn the language of ‘finance’.

In a house unit in Munich where the heating demand of the existing building was four times more than the proposed scenario, a new design was proposed with the construction of an energy façade, the TES Energy Facade, a prefabricated timber construction system for remediation methods that achieve an energetically highly efficient standard. The result is an important basis for a further development and a smooth workflow and cost-effective, ecological, energy efficient method for optimizing the building envelope. During the whole process of the project, the team had to deal with numerous obstacles and risks, but it is crucial and very important to have the occupier’s involvement.

The following table illustrates important data measured and/or calculated before and after the renovation.

<table>
<thead>
<tr>
<th>Table 4. Measured and/or calculated values before and after the renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Dates (The existing was built at 1958)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Net Dwelling Area</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Residential Units</td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Envelope Qual. Ht'</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>End Energy (measured)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Primary Energy (calculated)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The photos above present the external view before and after the renovation with the addition of the TES Façade system,

(Source: www.e2rebuild.eu)
7.7 Case 7: Tour Bois Le Pretre, Paris

The transformation of Tour Bois Le Pretre (Figure 3) by the French architect Frédéric Druot is a significant example of deep renovation combining energy retrofit with architecture quality and social sustainability.

It consists of a radical transformation of a tower building in a suburb of Paris, constructed on 1962 by the architect Raymond Lopez. The building is developed on 16 levels (50 m height), which accommodates 4 to 8 residential units in each floor, almost 100 in total. The 1999 new law in France enforced external insulation to the whole building and as a result, the interior spaces were decreased. The result of the addition of pre-fabricated extensions, winter gardens and balconies on a lightweight façade was the extension of two meters of living space and one meter of balconies. The construction of the new façade and the volumetric addition resulted in an increase of space for balconies and sunspaces for existing units, an additional increase of space in existing units, with a consequent growth of the tenants’ number. In parallel, the energy performance of the building has been powerfully upgraded. By the addition of the sunspaces and the winter gardens, the original surface of 8900 m² resulted to 12460 m² and the new organization of the apartments, the technical improvements and mainly the addition of the winter gardens led to the reduction of the energy consumption to almost 50%.
The photos above present the external view before and after the renovation of Tour Boid le Pretre, Paris

Plans of the existing building and the volumetric addition on top, axonometric view of the replacement of the existing façade with the sunspace on bottom
The photos above present the internal views of the apartment before and after the renovation.

7.8 Case 8: Vejgaard residential district, Aalborg

An outstanding example is given by the renovation projects by C.F. Møller Architects, whose work is focussed in architecture transformation as an essential social-oriented driver for renovation.

In the district Vejgaard in Aalborg stands a 12-floor apartment building surrounded by a series of lower buildings owned by Himmerland Housing Association (Figures 6 and 7). A social-oriented renovation involving the building and the whole area was proposed in a typical social housing building block constructed during the 70’s- 80’s. It was part of the social aspect that all blocks would be designed according to different scenarios1. Different types of volumetric solutions were analysed. (Addition of balconies, winter gardens, roof top extension etc.) The additional facade provides an energy-saving buffer zone, added living spaces according to different users’ requirements, and the is a new building representing an architectural reference for the region.

Before renovation, the tower block had several construction problems, including thermal bridges, damage to the concrete structure, penetration of moisture and lack of insulation; therefore, energy renovation has been combined with an extensive renovation involving the constructive, architectural and social components as a whole. The new layer with balconies and galleries creates a transition zone between the existing building and the envelope that works as a buffer zone. This new layer has been combined with standard renovation of the existing buildings. To further contribute to energy improvements, everything has been insulated to current standards, the old hot water system replaced and new domestic water heat exchangers installed. The apartments have natural ventilation, combined with mechanical exhausts from bathrooms and kitchens, and all apartments now have individual meters for water, heat and electricity. Although data from energy consumption are not yet available, a reduction up to 45-50% is expected.

http://www.cfmoller.com/
The photos above present the external views before and after the renovation of the residential district Vejgaard in Aalborg and internal view of the added sunspace on the top.


7.9 Case 9: Tower Weberstrasse, Winterthur

An extension and refurbishment of a residential Tower Weberstrasse, Winterthur over the full height and width of the rear facade is planned by Bulkhalter Sumi architekten for an existing 12 level apartment tower, built at the 60’s by Architect H. Isler 2.

The so-called “backpack” strategy was applied. The strategy consists in the addition of new units combined to the energy refurbishment and the typological renovation of the building. The main aim of this project was the increase of the rentable surface. The architect mainly focused on maintaining the existing footprint, preserving green areas and reusing existing infrastructure. By adding a new volume at the rear of the building,

the external space - with its arboreal heritage typical of the fifties garden city - was preserved, with a minimal impact in terms of surface’ settlement. De facto, the existing north facade is refurbished by the extension: with the new volume on the north front, with its slightly convex profile evoking the idea of a “backpack”, the existing stairwell can also be used to access the new structure. Furthermore, the extension improves the compactness of the building, secures its static and seismic safety and acts as insulation for the existing north façade. The existing four small apartments of each level are grouped together and converted into two new larger units.

Inspired from the section of Le Corbusier’s Unité d’habitation, duplex apartments are installed in the new volume with large overhanging balconies facing East and West. The ‘backpack’ addition strategy with the new layer on the north, the overhanging balconies and the new texture on the South façade, with the different colour of the plaster on the horizontal parapets and the vertical bands of masonry, create an interlacing pattern and a new identity to the building. (Figure 8)

The photos above present the external views before and after the renovation of the residential Tower Weberstrasse, Winterthuron the top. Architectural plans before and after the volumetric addition on the bottom.

(Source: http://www.burkhalter-sumi.ch/projects)
In the case study of Tower Weberstrasse3, the measured energy consumptions calculated on the heated surface of 3887 m² before the renovation was 604244 kWh/y. This consumption results in 155 kWh/m² per year in terms of gas consumptions. After the renovation the calculated energy consumptions account for a global 61,5 kWh/m² per year, considering a total increased surface of 4.830 m², thus including the addition.

In all these three examples, the additional space led to the variation of the existing housing, the addition of a greater sense of security and at the same time upgrading the social life of the community, since the owners were often included during the whole procedure. New “envelopes” often consist of architectural spaces and units: the new layers with the winter gardens, the extra balconies and galleries create a transition zone between the existing building envelope and the external weather conditions and that results, as reported in the reference cases to a consistence decrease of the initial energy consumption.

7.10 Case 10: Residential Building in Doha, Qatar

This project, though outside of the EU, is most interesting regarding the occupant`s value of architecture regarding the indoor environmental quality. It was developed by OMA architects in 2012 and is listed in ‘Form follows Energy: using natural forces to maximise performance’ (Cody, 2017).

This project provides an extraordinary example how architectural passive measures combined with active measures support a comfortable indoor environment. The multifunctional roof incorporates a concrete solar absorber, thermal solar collectors, photovoltaic modules and daylighting elements. A concept combining water walls for cooling and dehumidification with natural ventilation was developed. The solar absorbers on the roof provide energy for cooling.

The drawing above presents the House in Doha, architectural passive combined with active measures for a better indoor environment for the occupant

3 TEC21, Dossier Maerz 2010, bauen fuer die 2000-Watt-Gesellschaft}
7 Conclusion

This study investigated the value ‘good’ architecture might bring to a construction project and built result. It set out with an overview of the various perceived values of architecture, the different perceptions of stakeholders, the plethora of scales, levels and metrics used to measure it. The criteria found in literature are listed in Table 1 and categorised into seven main areas: economic, ecological, heritage, health and well-being, social, functional and cultural. In order to stay in line with the TripleA-reno project objectives the value of architecture during a residential renovation project for the occupant/owner is selected as the main focus of this study.

As a next step a plethora of EU funded projects was examined in order to investigate whether the value criteria and areas previously identified were already researched in these projects. A list of 13 projects, which could be connected to the focus of this study were identified in Chapter 3 and further elaborated in Chapter 4. Indeed, there are some projects including the architectural value in their rationale and some of their results. Yet, none investigates the value of good architecture in residential renovation projects as their main focus. Chapter 4 aims at linking the project results to the value of architecture. A limitation can be seen, as the plethora of EU funded projects renders it almost impossible to include all projects. Research attempting this would be very time consuming.

This is followed by a brief digression on smart buildings, how they potentially change the architects work and their value for the occupants. The new EPBD includes an article on the smart readiness indicator, which is specifically important when examining the user experience of the built result. The chapter also includes the policy position on the SRI from the Architects’ Council of Europe.

Chapter 6 focuses on the extent to which the value of architecture is taught at European Architecture Schools to future architects. This is a vital aspect of the discussion, as in case the architect is not aware about the value s/he might bring to a project, how can an occupant or other stakeholder perceive such a value? This chapter begins with the analyses of a survey undertaken amongst European Architecture Schools, before going into more detail on four Universities, which are consortium partners in the TripleA-reno project (Budapest, Valencia, Bologna and Ljubljana). A striking result of the survey is that the economic value of architecture is the least taught area in the participating universities, while heritage is the most taught area. An investigation into the links between these results and the comparably low salaries of architects could provide interesting results.

The report concludes with best practice examples of residential renovation projects in which an architect was involved.

Research limitation can be found in the low participation of the survey on how the value of architecture is taught. It can be recommended to repeat the survey with a longer time frame in order to receive more respondents from more countries. Further research recommendations include strengthening the overall research design by conducting follow-up interviews with the universities on why the economic value of architecture is not taught enough.
8 References


Callway, R., Farrelly, L. & Samuel, F., 2019. The value of design and the role of the architects.. s.l.: ACE.


Fomento, M. d., 2015. Real Decreto Legislativo 7/2015, de 30 de octubre, por el que se aprueba el texto refundido de la Ley de Suelo y Rehabilitación Urbana. s.l.:s.n.


Hacienda, M. d., 2004. Real Decreto Legislativo 1/2004, de 5 de marzo, por el que se aprueba el texto refundido de la Ley del Catastro Inmobiliario. s.l.:s.n.


Serin, B., Kenny, T., White, J. & Samuel, F., 2018. *Design value at the neighbourhood scale. What does it mean and how do we measure it?.* s.l.:UK Collaborative Centre for Housing Evidence.

The Architects’ Council of Europe (ACE), 2018. *20 Architectural Projects against Climate Change.*, Brussels: ACE.


## Appendix 1: Selection of courses that include the value of architecture in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>University</th>
<th>Economic</th>
<th>Ecological</th>
<th>Social</th>
<th>Functional</th>
<th>Cultural</th>
<th>Well-being</th>
<th>Heritage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>Évora University</td>
<td><a href="http://eartesportfolio.uevora.pt/arq-aluno.html">http://eartesportfolio.uevora.pt/arq-aluno.html</a> Integrated Master in Architecture - Design Studios</td>
<td>same as previous</td>
<td>same as previous</td>
<td>same as previous</td>
<td>same as previous</td>
<td>same as previous</td>
<td>same as previous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>Universidad Politécnica de Valencia</td>
<td>Proyectos 3 Taller 4</td>
<td>Taller de Proyectos 4 Taller de Urbanismo RT, TUR</td>
<td>Taller de Proyectos 4 Taller de Urbanismo RT, TUR</td>
<td>Taller de Proyectos 4 FISA</td>
<td>Taller de Proyectos 4</td>
<td>Taller de Proyectos 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td>Fundamentos de la Arquitectura</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td>Master's degree in architecture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structure I</td>
<td>Landscape</td>
<td>Projects</td>
<td>Urbanism</td>
<td>Urbanism</td>
<td>Construction</td>
<td>Construction</td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>Degree subjects such as Conditioning and Services I. MBArch Master studies, line Architecture, Energy and Environment</td>
<td>Architectural Design subject during the Degree studies</td>
<td>Several subjects in Degree studies</td>
<td>History and Composition</td>
<td>Conditioning and Services I subject of Degree Studies</td>
<td>Architecture and heritage, construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>----------------------------------</td>
<td>------------------------</td>
<td>--------------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universidad Politécnica de Madrid</td>
<td><a href="http://duyot.aq.upm.es/master/muput">http://duyot.aq.upm.es/master/muput</a></td>
<td><a href="http://duyot.aq.upm.es/mastemuput">http://duyot.aq.upm.es/mastemuput</a></td>
<td>Project courses. Always Project courses</td>
<td>Project courses. Daylight was indeed a very important subject to consider. Also &quot;Urbanistica&quot; courses.</td>
<td>Project courses. Amenities were not well considered. They had to be artistic. Functional amenities were considered kitsch</td>
<td>&quot;Restauracion&quot; courses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escuela Técnica Superior de Arquitectura de la Universidad de Granada</td>
<td>From &quot;Projects IV&quot; to &quot;Projects VIII&quot; because they were supposed to deal with all of the subjects involved in an architectural project. Also on the &quot;Urbanistica&quot; courses we taught something about gentrification</td>
<td>&quot;Project&quot; courses. Also &quot;Instalaciones&quot; courses</td>
<td>Project courses. Daylight was indeed a very important subject to consider. Also &quot;Urbanistica&quot; courses.</td>
<td>Project courses. Amenities were not well considered. They had to be artistic. Functional amenities were considered kitsch</td>
<td>&quot;Restauracion&quot; courses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>The University of Sheffield</td>
<td>Professional Practice taught in Year 3 BA Hons Architecture, but also in Studio and in Year 3 again in ARC307, and again in studio in M.Arch</td>
<td>These aspects are taught in all our studio work, and particularly in M.Arch studios</td>
<td>We teach these aspects as a matter of course in all our studio work, from year 1 onwards. We also teach it through supporting modules such as our technology modules.</td>
<td>See as previous answer.</td>
<td>We teach the in our studies, with a specialist studio on this in our M.Arch programme. We also support these aspects through our Humanities modules which support our studies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Reading</td>
<td>History and Theory 1 AAH HT1 the webpage is private to members of UoR</td>
<td>Again History and Theory 1 H &amp; T 1</td>
<td>H &amp; T 1 also History &amp; Theory 2 buildings and Places</td>
<td>H &amp; T 1 AAH HT1 again</td>
<td>History and Theory 1 AA1 HT1</td>
<td>History and Theory 1,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oxford Brookes University

Real Estate and Construction, Property Development, Planning

School of Architecture, across UG and PG modules

The PG modules in School of Architecture

School of Architecture, across UG and PG modules

School of Architecture, across UG and PG modules

School of Architecture, across UG and PG modules