eurac research

SBE Series

SBE21 Sustainable Built Heritage

14-16 April 2021,
Online conference

DRAFT PAPER

The SBE21 Heritage Conference is co-financed by:

International co-promoters:

Under the patronage of:

In collaboration with:

Swiss case studies examples of solar energy compatible BIPV solutions to energy efficiency revamp of historic heritage buildings

C S Polo López[1,2], M Mobiglia[1]

[1] Department for Environment Construction and Design (DACD), University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Via Francesco Catenazzi 23, CH-6850 Mendrisio, Switzerland
[2] Corresponding author, cristina.polo@supsi.ch

Abstract. Nowadays the proper use of energy towards ever major energy efficiency is a topical issue also for heritage buildings (hereinafter HB) which have special value both as a material testimony of our past and as a cultural asset. Greater open-mindedness to find compatible integrated solutions to improve the sustainable use of our built heritage is growing which consider, not only revamping the structural integrity, the indoor air quality and user comfort, even appraise benefits on using innovative materials or construction techniques to increase energy efficiency and exploit renewable and solar energies. Technological advances in Building-Integrated Photovoltaics (BIPV), hybrid photovoltaic thermal systems in combination with other renewable resources can be used as support for other smart measures applied to the historic building envelop, windows or the HVAC and ventilation systems. Main findings based on documented examples of best practices clearly demonstrate the maturity of these solutions and will be presented. This study in Switzerland in the framework of two Interreg projects allowed to collect documentation on case-studies with a high standard energy concept, from net zero energy (NZEB) to positive energy buildings (PEB), which demonstrate how solar BIPV technologies can be well-integrated to enhance energy efficiency in historic buildings

Keywords – Heritage Buildings; NZEB and PEB; renewable energy; solar energy; building integrated photovoltaics BIPV

1. Introduction

The recent EU policies a target for RES penetration to 32% by 2030, as stated in the recast Renewable Energy Directive [1], which sets framework conditions for renewable energies in the electricity sector (RES-E) and the requirements for the policy design of support mechanisms of renewable heating and cooling (RES-H/C). The revised Energy Efficiency Directive (EU) 2018/2002 [2] as part of the 'Clean energy for all Europeans package' sets an energy efficiency target for 2030 of at least 32.5%. As part the European Green Deal (EGD) policies that aims at becoming climate-neutral by 2050, a set of binding measures to help EU Climate Target Plan to achieve a level of greenhouse gas emission reductions of at least net 55% are promoted [3]. Unfortunately, the coronavirus (Covid-19) disease has created the biggest global crisis affecting also the energy sector in all countries over the world slowing transport, trade and economic activity [4]. Despite this, it is shown that clean energy transition must be at the center of economic recovery plans to build secure and sustainable energy systems, as part of e Next Generation EU recovery plan [5]. Therefore there is a need to significantly step up energy efficiency efforts. Buildings account for 40% of energy consumed and till now the annual renovation rate of the building stock varies from 0.4 to 1.2% in the Member State [3]. EU will foster double this rate to reach the energy efficiency and climate objectives. To address this challenge Member States should engage in a 'renovation wave' of public and private buildings in order to lowers energy consumption and energy poverty and boosting, at the same time, the construction sector and local jobs as opportunity for SMEs [6]; [7]. EU's Recovery and Resilience Facility (RRF) [8] is the key recovery instrument at the heart of NextGenerationEU strategy which plans investment and reforms in the following flagship areas "Power up" and "Renovate" among others, to further increase clean technologies and acceleration of the development and use of renewables and boost improvement of energy efficiency in buildings [9]. In parallel, owners of old buildings struggle to keep their homes warm safety and comfortable. The quality of life and well-being of people, as well as reduce resource use and greenhouse gas (GHG) emissions forward-looking, is the ambitious vision for an economy geared to the UN Sustainable Development Goals will give priority to clean infrastructure investment in the form of renewable energy assets, storage (including hydrogen), energy grid modernisation, as well as pushing for building efficiency supporting new funding's schemes for renovations and retrofits including improved insulation, heating, and domestic energy storage systems, etc. [10]. This work demonstrate the path to follow. Some examples of renovated historical buildings (protected and not-protected) in Switzerland has been studied where renewable energies (solar, geothermal or biomass energies) are couple with other refurbishment technical measures to achieve high energy efficiency standards and comfort.

2. Renewable energy and renovation high efficiency measures in Swiss historical buildings

A successful energy refurbishment is one that manages to keep the historic substance in good condition and achieve long-term energy improvement to achieve, as much as possible, net zero-energy building (NZEB) targets, also possible for historic buildings. Efficiency measures commonly used include free solar gains, advanced insulation, reduced thermal bridging, air tightness, use of the thermal mass, daylighting and ventilation strategies, or energy-efficient lighting and appliances. At these point, the remaining and low energy needs, could be satisfied using renewable energy generated both on- and off-site of the buildings, increasing the cost-effectiveness by reducing the size and capacity of the renewable system required [11]. In Switzerland, solar energy is the fastest-growing energy source and solar photovoltaic (PV) exhibits the largest potential, from 3.4% to 20% by 2050 that seems to be realistic, since PV faces much less opposition than other renewables, representing a challenge in HB. Within the framework of the Interreg Alpine Space "ATLAS" [12] research project and the International Energy Agency Solar Heating and Cooling Program IEA-SHC Task59 / IEA EBC Annex 76 activities [13], in-depth information on 10 case-studies of renovated historic buildings in Switzerland, mostly recognized with the Swiss Solar Award (Solar Agentur Schweiz), has been collected providing a comprehensive visual on success aspects for achieving high standards on energy retrofitting. The projects will be available on an online web platform to advertise model projects all over the world [14]. The case studies chosen are representative projects in favour of a rational use of energy, low-emission or emission-free, which promote renewable energy and in particular the use of solar energy and BIPV in historic buildings some listed in federal and cantonal inventories, in protected areas or not listed but with worthy elements of being preserved. The retrofit intervention followed the results of a thorough heritage value assessment and a significant energy demand reduction was achieved. Among this case-studies, retrofit solutions and strategies, which fulfil both, the conservation compatibility of historic buildings as well as energy efficiency goals towards lowest possible energy demand (NZEB) were documented with a specific focus on: (i) windows solutions, (ii) internal wall insulation, (iii) ventilation and (iv) HVAC and renewable energies, including solar systems (v). Further information specifically for the implementation of solar BIPV in historic buildings and sites, or protected landscapes, was collected thanks the participation in the Interreg V-A Italy-Switzerland research project "BIPV meets history" [15] and disseminated through and disseminated through the international www.solarchitecture.ch web portal.

2.1. Case-studies overview: BIPV implementation to energy efficiency revamp of Historic Buildings

Although less than 10% of the Swiss building stock has a special value as a material testimony to our past and as a cultural asset (those listed or protected in inventories) in most cases, energy improvements are possible. However, in order for this to succeed without losing substance and historical significance, a dedicated engagement with the task is required considering an interdisciplinary process, through the collaboration of multiple experts [16]. In order to energetically adapt a monument without damaging it, it is necessary to know how it works and treat it as a unit, in particular knowing the interactions between construction, ventilation, heating, indoor climate, hygrothermal balance but also with the integration of new technical solutions, as for example the solar energies (photovoltaic PV, building integrated photovoltaics BIPV or solar thermal systems), considering their possible contribution in the overall energy balance of the building itself. Knowing these aspects makes any restructuring planning easier. Therefore, there is a connection between construction and energy, which is often a balance that can be seriously disturbed by negligent interventions, with negative consequences for the property. Furthermore, it has already been shown that energy-efficient buildings achieve a higher economic value (i.e. more sale or rent incomes or in terms of levels of occupancy, due to best comfort levels and less energy costs). In the historical building, the renovation measures and strategies for energy recovery must be adapted to the existing building and to the circumstances and in some cases a high standard energy concept, from net zero energy (NZEB) to positive energy buildings (PEB) were shown in the examples documented. Analyzed examples can grouped as follows: a) Monuments (e.g. palace, castle or unusual buildings); b) Villa and single family houses (SFH); c) Public buildings (e.g. asylum, church, and offices); d) Rural building and farmhouses; e) Industrial buildings; f) Multi-family houses (MFH) and apartment blocks. Main achievements of each category have been summarized below and in Table 1:

a) The **Doragno Castle** (Figure 1) was born from the transformation of an ancient medieval castle into a private residence in 2014 where the existing building, which did not enhance the castle, has been subsequently restored in 2018. It was a part of a path bordered by fortified castles and watchtowers in the Alps. This private not-listed historic residence in Ticino, achieved a NZEB target using also solar renewables energy. An integrated solar photovoltaic BIPV system and solar thermal collectors (BIST) were installed on the roof. The architects have re-created the shape of the castle using modern materials considering todays comfort standards by chosen to preserve only the medieval part of the building because the previous interventions hiding the ancient parts The original stone walls are highlighted by the large windows that complete the volume of the existing building. The cultural heritage office supervisors approved the project and agreed with reflections and considerations from architects. Intervention and running cost are not available. Main strategies to highlight are:

- The restoration project complete what remained of the walls and tower of the **Castle to return the original shape using internal insulation,** so that in the surrounding landscape the building of **the past once again became legible.**
- **Reversible air-water heat pump powered by the photovoltaic (BIPV) system** on the roof is used for thermal and cooling. Distribution is made both from radiating floors and fans bellow a raised floor (Floortech patent, deltaZERO concept), dry laid and demountable, giving flexibility. DHW thanks solar thermal becomes completely free and renewable.
- The **integration of solar systems (BIPV+BIST) consider aesthetic and geometry** as aspects **to minimize visibility** from the surrounding environment.

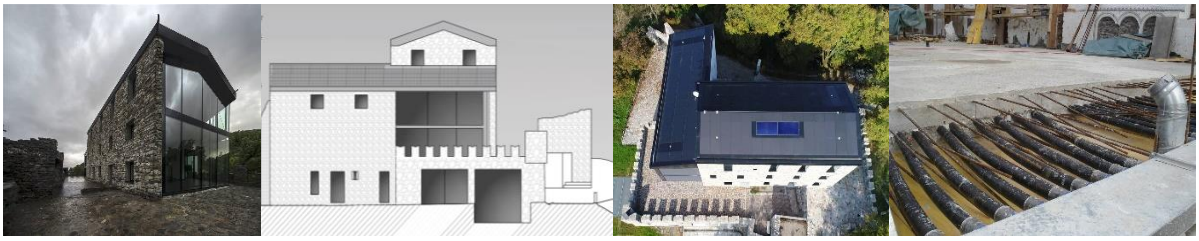

Figure 1. Doragno Castle (TI-CH) restoration achieved NZEB target. Source: deltaZERO SA, De Angelis - Mazza Architects, Photo: © Luciano Carugo.

b) The 1898 **listed building Hutterli Rothlisberger** (Figure 2), a single family neo-baroque house (SFH) in Bern/BE, was extensively renovated between 2011 and 2015. , the installation of a photovoltaic and a solar thermal system, as well as the replacement of the gas heating system with a heat pump, geothermal probes and a stove. Thanks to the renovation, the total energy requirement fell by 76% from 46'900 kWh per year to 11'100 kWh/y. On the upper roof surface, a BIPV+PVT a photovoltaic–thermal system with an electrical output of 2.7 kWp supplies around 3,200 kWh/yr of electricity. Thus 13m^2 of solar thermal natural slate collectors were installed, which corresponds to an output of about ~5kWp. The solar thermal system generate about 10'000 kWh/yr of solar heat. This renovation deserved the Swiss Solar Prize 2014. The general situation of degradation and the need to minimize energy demand collided with the important aspect of historic buildings preservation. Due to the high protection level of the building, it was initially difficult to receive approval from the authorities, however this led to the search for the best possible solution. Total cost of energy related interventions were CHF 200'000 that includes: roof (CHF 45'000), walls, doors, windows and insulation cellar. The owners, involved directly were able to keep some costs down. Main strategies to point out are:

- Several **high efficiency interventions, but with minimum aesthetic impact** (e.g. external insulation with a double-shell blowing system with Isofloc H2Wall plus 1cm aerogel insulation, a premiere in Bern, that maintains wall original aesthetics without increase the thickness).
- The **intervention on the original windows** includes renovations and replacements that respect the original appearance.
- A comfort **ventilation system with heat recovery** in combination with a new thermal system by renewable energy (geothermal proves and biomass).
- Solar panels, **BIPV+PVT+ST system under natural slate roof are slightly visible** from the street, leaving part of the original slate roof intact.

Figure 2. Hutterli Rothlisberger SHF (BE-CH). Source: Beat Wermuth und Partner Architekten GmbH Photo: © Manuel Hutterli and Caspar Martig.

c) The **Palazzo del Cinema Locarno project** (Figure 3) is guided by principles of economy, trying to capitalise the existing structure and the public affection for the former school, Palazzo Scolastico – a 19th century building completely renovated in 2017 – that now hosts a variety of NGOs and cultural associations, to provide an architectural identity for the new cinema complex. The PalaCinema is a multicultural platform for the cinematic arts located in the historical core of the Swiss city of Locarno that hosts each year the Locarno Film Festival, so this building is of particular importance. The original building needed to be restored and brought back to life while maintaining its external historical appearance, as it is part of a protected area. This building is now a landmark in the city thanks an urban recycling strategy of the entire area. For the approval of the final project of this public building, there was a political will to social and urban revitalize an area of the city of great importance. A solar plant of 135.7 kWp and an estimated annual production of about 130'000 kWh/yr was installed on the roof. The total cost of PV plant were CHF 178'000. Total refurbishment cost were CHF 33'651'600. Works have been financed by the City of Locarno, Cantonal contributions and by different tourism and cultural sector Foundations. Main aspects to be highlighted are:

- The former **municipal schools brought back to life** reconverted **to revitalize a public space** in the city core of **new social and cultural utility**.
- Architects aimed at substantially **reduce CO_2 emissions caused by construction, demolition and transport activities**.

- **Minimum thickness of insulation on internal walls** to reach Minergie® label for low energy buildings (less than 38 kWh/yr). The original façade remains exposed but treated with a plaster in white to allow images to be projected onto but keeping part of its original expression alive.
- **100% indirect Ground Water Heat Pump (GWHP)** for heating/cooling and domestic hot water in combination with the solar PV plant.
- A **bidirectional east-west solar plant** in the roof (759 m^2 that produce 142'000 kWh/yr) **allows better distributed energy production** throughout the day **and lower visual impact**.

Figure 3. Public building PalaCinema Locarno (TI-CH). Source: AZPML+DFN (architects consortium), Locarno City and PalaCinema SA. Photo: © AZPML and Greenkey Sagl

d) The aim of the refurbishment project in 2015 of a **rural building Glaserhaus** from the 1700s (Figure 4) in Affoltern im Emmental were to repair the existing unused traditional building and back to live the original condition. This restoration is connected with the aim of preserving the overall appearance of the building, repairing the roof, facades and surroundings and carefully restoring the prestigious south façade. From a technical point of view, the building were solidly stabilized and energetically brought up to the latest standards. The project was developed with the involvement of the cantonal monument preservation authorities due to its high level of protection. Several meetings and inspections took place to further develop the project in accordance with their requirements. Total investment cost amounted of a total CHF 2'800'000 including building and surroundings. Energy related interventions cost CHF 745'000 that includes: insulation floor, walls, roof, windows, PV, heat pump and boreholes. Main aspects to be underlined are:

- The **façades have been restored and thermally insulated between the wooden rafters** to achieve the Minergie-P standard (very low energy consumption).
- **The roof shape is returned to its original shape** to ensure the load-bearing capacity and with **new insulation to avoid energy losses and potential cold bridges**.
- **RES implementation: groundwater heat pump (GWHP)**, geothermal boreholes and DHW system is integrated in the heating system plus an **integrated BIPV solar system in the roof**.

Figure 4. Rural building Glaserhaus (BE-CH). Source: Anliker Christian, Arch/Innenarchitekt SWB. Clevergie gmbh. Photo: © C. Anliker

e) The coal **Solar Silo "Kohlesilo"** (Figure 5) dating 1800s of the Sulzer and Burckhardt machine factory in Basel has been modernized in 2014 and was completely converted into a multi-purpose building. As part of a research project this best practice building investigates new approaches for

BIPV integration as cladding innovative materials and new energy storage strategies. As "Gundeldinger Feld" ensemble is under heritage protection, the remodeled building was required to match the style and colour scheme of the site and all the old industrial area has been reconverted in a new model energy district. Total investment cost amount of a total CHF 1'200'000 including PV plant (about 125'000 CHF) and heating system (38'000 CHF). Specific Cantonal funding instruments covered part of the costs and Swiss Federal Office of Energy gave financial support for the coloured BIPV modules, building energy services (BES) and monitoring. The project is part of the "2000 Watt society - pilot region Basel" and Swiss Solar Prize 2015. Main opportunities were:

- **Socio-cultural revitalization** of "Gundeldinger Feld" ensemble which is under heritage protection. The complete industrial area has been reconverted in a new model energy district.
- **Innovative colorful PV** modules are used creating a particular visual design as part of a research project which monitors the battery energy storage system.

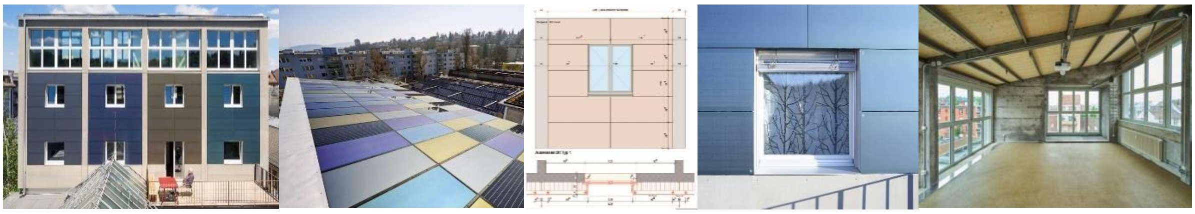

Figure 5. Industrial building Solar Silo (BS-CH). Source: baubüro in situ ag (Kerstin Müller), Locarno City and PalaCinema SA. Photo: © Martin Zeller

f) During the refurbishment in 2009 of the **multi-family house (MFH) Feldbergstrasse** in Basel (Figure 6), a building dating from 1850, several requirements of the cityscape commission for façade and roof design had to be met. The challenge was to operate a 6-storey residential building with 12 apartments as completely as possible with solar energy in the protected zone of Basel-Stadt. The entire heat energy requirement (hot water, heating, home ventilation and auxiliary energy) is covered exclusively by the solar energy on the roof of the building. Total investment cost amounted of a total CHF 5'000'000 including demolition, building's retrofitting, solar systems, surrounding and additional costs. Energy related interventions cost CHF 500'000 that includes: insulation, plants (Heat pump, PV panels, solar thermal ST and ventilation). The total cost of PV plant was CHF 125'000.

- To **meet requirements of the cityscape commission for façade and roof design** in the protected zone of Basel-Stadt;
- **Plus-Wärmeenergiehaus** - PHEB Plus heat energy building and total CO_2 emissions reduction of 64'000 kg/yr about 88.3% (*CO_2 emissions for electricity according to UCTE: 535g/kWh);
- The challenge was to **operate the building as completely as possible with solar energy**. The entire heat energy requirement (hot water, heating, home ventilation and auxiliary energy) is covered exclusively by the solar energy → **Energy costs are CHF 0.00.**

Figure 6. MFH building Feldbergstrasse (BS-CH). Source: Viridén + Partner AG. Photo: © N. Mann.

Table 1. Summary of main results achieved after renovation and investment cost per sqm.

	Swiss Case Studies	Protection level [1]	Energy standard	Self-suff. Rate	Energy performance (kWh/m^2yr)	Investment Cost (CHF/m^2)	BIPV Plant (kWp)	Cost PV plant (CHF/m^2)
a)	Monument Doragno Castle	3	NZEB	140%	45.62	NA	16.4	NA
b)	Single-family house SFH Hutterli	1	-	29%	35.22	775	27	1'429 [2]
c)	Public building PalaCinema	2	Minergie (NZEB)	63%	38.00	235	135.7	1'312
d)	Rural building Glaserhaus	1	Minergie-P (PEB)	345%	26.64	2'416	53	NA
e)	Industrial building Solar Silo	1	-	37%	66.00	1'783	24.0	786
f)	Multi-family MFH Feldbergstrasse	1	PHEB	17%	35.00	4'744	24	1'962

[1] Protection level: 1 Maximum level (listed buildings or in cantonal inventories); 2 Medium level (not listed but in a protected area or partially protected); 3 No protection.
[2] Cost BIPV Plant: The cost includes roof intervention cost: BIPV, PVTand STh natural slate collectors.

3. Discussion and conclusion

The examples studied showed that the energy demand could be notable reduced in historic buildings regardless of whether the building is has a higher level of protection reaching even the label for low energy buildings and plus energy, thanks to the synergies between renewable energies and the multiple integration of efficient retrofit solutions. The whole building has to be considered as an integrated system where renovation measures in the building envelope (i.e. improving the insulation of building fabrics, windows, roofs, etc.) works together with the domestic systems: heating, cooling, ventilation and hot water preparation with a rather reasonable combinations of other technological systems and strategies (e.g. heat recovering, efficient lighting and daylighting, etc.). After renovation, the Swiss historic buildings studied reach good Building Energy Rating (BER) which is an indication of the energy performance expressed as primary energy use per unit net floor area per year and equal to the new constructions varying 50 kWh/m^2yr to 25 kWh/m^2yr (lower most-energy houses). Besides, the integration of solar integrated photovoltaics (BIPV) and solar thermal or solar hybrid PVT panels can be well-integrated and conciliated with the historical character of old buildings. As shown in the examples studied the share of renewable energy needed to satisfy buildings' energy demand depends directly on the level of energy efficiency achieved after the renovation to reach a good compromise with the protection constrains, mostly in listed buildings or in protected areas. In most of the cases studied this have lead in an important energy self-sufficient rate. However, even though the information was well-documented thanks to the active collaboration of all stakeholders involved (i.e. owners, architects, engineers or energy consultants, public and heritage bodies) unfortunately, on-site monitoring post-intervention is still very rare and seems to be limited mostly to research related projects. Although financial aspects are often highlighted as both triggers (reducing running costs) and limitations (excessive investment costs) for carrying an energy renovation, unfortunately, not all the projects documented so far have enough information. Investment cost are higher in multi-family buildings (in the example due to a renovation dates many years ago) or lighthouse projects with innovative tech plants (e.g. public or industrial buildings) but it proves not to be a barrier for both good energy efficiency results in historical buildings and market competitiveness of specific solar products analyzed. The final aim of this work is to report a systematic analysis of case studies in order to make these resources available to citizens and to professionals to accelerate, in the Swiss real estate portfolio and in EU building stock "systemic renovations" with particular attention to historic buildings to achieve the objectives set for energy efficiency, sustainability and a 100% renewable society and find new retrofit approaches to save our common heritage and guarantee a sustainable future.

4. References

[1] European Parliament Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, *Official Journal of the European Union*, 2018. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=fr

[2] European Parliament, Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, *Official Journal of the European Union*, 2018. **156**

[3] Communication and roadmap on the European Green Deal (EGD),https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

[4] IEA (2020), Global Energy Review 2020, *IEA International Renewable Energy Agency*, Paris, [Internet]. 2020; Available from: https://www.iea.org/reports/global-energy-review-2020

[5] The Next Generation EU recovery plan: https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan - europe/pillars-next-generation-eu_en 4

[6] IRENA (2020), The post-COVID recovery: An agenda for resilience, development and equality, *International Renewable Energy Agency*, Abu Dhabi ISBN 978-92-9260-245-1

[7] The EU Just Transition Fund: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism_en

[8] EU Recovery and Resilience Facility (RRF): [Internet]. 2021; Available from: https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1658

[9] Amendments adopted by the EP on 17 September 2020 on the proposal for a regulation establishing the Just Transition Fund, [Internet]. 2021; Available from: https://www.europarl.europa.eu/doceo/document/TA-9-2020-0223_EN.htm

[10] Stagl S, 2020, Opportunities of post COVID-19 European recovery funds in transitioning towards a circular and climate neutral economy , IPOL:BRI, *Directorate-General for Internal Policies*. PE 658.186, doi: 10.2861/57926

[11] Torcellini P, Pless S and Deru M, 2006, Zero Energy Buildings: A Critical Look at the Definition, *ACEEE Summer Study*, Pacific Grove, CA, 14-18 [Internet]. 2021; Available from: www.nrel.gov/docs/fy06osti/39833.pdf

[12] ATLAS, Advanced Tools for Low-carbon, high-value development of historic architecture in the Alpine Space, https://www.alpine-space.eu/projects/atlas/en/home

[13] IEA-SHC Task 59, Deep renovation of historic buildings towards lowest possible energy demand and CO2 emission (nZEB), http://task59.iea-shc.org

[14] HiBER ATLAS platform: https://www.hiberatlas.com/en/welcome-1.html

[15] BIPV meets history: Value-chain creation for the building integrated photovoltaics in the energy retrofit of transnational historic buildings, http://www.bipvmeetshistory.eu

[16] Polo Lopez C and Frontini F 2014 Energy efficiency and renewable solar energy integration in historical buildings heritage, *Energy Procedia*, **48** (168) 1493-1502.

Acknowledgments

The Authors wishing to acknowledge the assistance in the collection of information done by interns Floriana Troia (UNICT, University of Catania); Ahmed Hegazi and Chiara Bottani (ISAAC SUPSI). The research leading to these results received co-funding from the European Union, European Regional Development Fund, as part of the Interreg Alpine Space Programme for Atlas project, ID: ASP644 and is co-founded within the framework of the NPR (SECO) through the Regional Development Fund and coordinated by the Federal Office for Spatial Development (ARE). “BIPV meets history” Project (ID n. 603882) is co-financed by the European Union, European Regional Development Fund, the Italian Government, the Swiss Confederation and Cantons, as part of the Interreg V-A Italy-Switzerland Cooperation Program. Participation to IEA-EBC Annex 76 / IEA-SHC Task 59 research has been carried out with the support of the Swiss Federal Office of Energy (SFOE), Contract no.: SI/501896-0. Special thanks to the owners, architects and engineers for providing with the essential content and documentation of the case studies giving permission to publish them, as well as, to www.solarchitecture.ch and BIPV team within SUPSI, for supporting the dissemination.