Newness Touches Conventional History: The Research of the Photovoltaic Technology on a Wooden Church Heritage Building

Diţoiu Nina-Cristina 1, Mihaela Ioana Maria Agachi 1, Mugur Balan 1
1 Department of Architecture and Urbanism, the Technical University of Cluj-Napoca; 34-36 Observator street; 400489, Cluj-Napoca, Cluj county, Romania
mugur.balan@termo.utcluj.ro

Abstract. The case study that determined the present research is the restoration of one Transylvanian wooden church from Cojocna, Cluj county, Romania. The original design (2018, Aqua Prociv Proiect Romanian company's project) assumed all ICOMOS’s charters and the recommendation from this area in quality design, and it is in the stage of the execution auction. After nowadays standards, the restoration work does not need to achieve any form of energy efficiency, and its primordial target is the preservation of historical values and many other essentials for Humanity. The risk of museification of the heritage buildings with this architectural function, church, can sustain different and relevant points of view about the restoration, as could remark in the Leeuwarden Declaration (23 November 2018). There are some essential theoretical concepts linked or not to this specific domain, as art, history, or philosophy, otherwise that can sustain the potential of this kind of intervention. The insertion of new materials in heritage works is not in the current practice of restoration. However, there is a need to adapt to the in changing world and within his changing needs—evaluation on the evolution of some building parts in the context of the technological revolution. We propose a study for the change of finishing roof material with the maintenance of the roof geometry or structure. The new material is the PV solar roof tiles. The numerical values for electrical energy produced with photovoltaic technology will appear evaluated with a homemade computer program validated by comparison with dedicated software (PHPP_V9.6; PVsyst 6.8.6). Other arguments from theoretical and more subjective points of view will also notice. Conclusion: The research started in the nowadays context from the sustainability area, and one question that appears natural was about how close to regenerative design can be achieved through restoration works.

1. Introduction
The case study that determined the present research is the restoration of one Transylvanian wooden church from Cojocna, Cluj county, Romania[1]. The original design, a project of a Romanian company that started in 2014 with the design that we finished in 2018 (illustrated in figures 1-2), assumed ICOMOS's charters [2] and the recommendations from this area in quality design and now working to the execution auction.

After nowadays standards, the restoration work target is the preservation of historical value and many other humanity essential values but does not need to achieve any form of energy efficiency or any other sustainability target. According to the Leeuwarden Declaration [3], the risk of museification of the church heritage buildings can sustain even different and relevant points of view about a restoration. This church in this debate is near the village cemetery, a buffer area between two different communities ethnically and socially. Each of them built a new church and appeared the issue of the museification:
nowadays, this heritage church is used a few times in a year. The revival potential we underlined is into the ancestral tradition of the table of the oldest-wiser / just needy people of the village, the existing poplar wooden table on the southern veranda. It could be involved the new local community in a new social project: a BIPV system that returns the gain energy to the sparse population, and also a meeting point for the community’s members at the ancestral poplar table.

Art History Professor Nicolae Sabau studied the Cojocna wooden church in 1979 and updated the study through his historical survey in 2014. Appear as “a building with a pronaos and the nave placed within a rectangle, having, to the east, a polygonal apse” built between ‘1794 and ‘1796 years “in the "Blockverband" techniques,” [4] The wooden church supported in 1875 significant interventions - the enlargement on the horizontal direction of the naos space, the rising in the vertical direction with a new tower. The 1875’ year restoration work reduced the entrance from the southern veranda to a window. These horizontal and vertical carved logs that delimitate the initial door entrance were partially destroyed. The new modern west side entrance got an unspecified aesthetic even for restoration's period, more specific to the next century. According to the historical survey, many unwanted interventions were done in 1969, like covering the original wooden shingles with the galvanized sheet roof or the strengthening of the original stone foundation through the cast in the exterior of the concrete perimeter.

We consider to analyze the possibility of a future new intervention to a vernacular heritage building from two different perspectives:

I. the first version as the design that nowadays is in execution with a wooden shingle roof that follows to rebuilt in the next years as a maintenance intervention;

II. the second version with the replacement of the wooden roof shingle tiles with the new PV solar roof tiles.

The best definition of the two perspectives is one of Hundertwasser's sketched metaphor[5]. He completed the initial three Man's skins (the epidermis, the clothes, the houses) defined in '70 years through the "Pictogram Man's Five Skins" in 1997 with the fourth, Identity (family/country) and the fifth, the Earth (nature/biosphere/planetary skin), linked to Sustainability. The last two "skins" connected between them, so nor of them is more important than the other. These will be the metaphors dedicated to the two design versions.

David Seamon developed a way to research for understanding a "Place Identity" after J.G. Bennett's systematics[6]. In a few words, more a glossary, not even a summary, he proposed the "people-place triad" — "genius loci (gl), geographical ensemble (ge), people in place (pp)"— to be identified in order to understand the "Place Identity." Associated a group of three triads from the all six for "the being a place" - "(place identity (ge-gl-pp), place interaction (pp-gl-ge), place realization (gl-pp-ge))" and the rest of the three for "the becoming a place" -(place release (gl-ge-pp), place intensification (pp-gl-ge), place creation (pp-ge-gl)). "We assume with no other developed considerations in this paper that our case in order to the "Place Identity" could be assimilated to the one defined by the author, as a particular case where "the being a place" with a strong identity might be invigorated by "the becoming a place": the six triads as place event, the "place-genius loci-will be intensified." In order to \textit{wholeness of the place} is more of the "place intensification" by the first design version or more of the "place creation" by the second design version.

2. Identity versus Sustainability

In technical terms, the insertion of new materials in heritage works is not in the current practice of restoration. There are some theoretical concepts not linked to this specific domain of conservation about the newness from the traditions in art, history, or philosophy. These will be remembered to validate the second version of the restoration intervention. The innovation as an old story or a forgotten one is a recurrent theme that Huderwasser sketched as a well-known quote: "If we do not honor our past, we lose our future. If we destroy our roots, we cannot grow." In the technological revolution context, the historical evolution of some building parts is to be evaluated even in the restoration area. A. M. Dabija studied the roofs in the Romanian context. She noticed not only the variants of materials in the covering the buildings but also the changes in Romanian roof finishings through the history of the same building,
a heritage building. Professor A. M. Dabija refers to the small "historic churches" in very forceful terms of "genuine architectural jewels, the principle behind the buildings being that the God is close to us and His house is at the human scale." [7] It is also essential to notice that the original roof on our study building was wooden shingle, partially preserved under the nowadays metallic roof. The galvanized sheet roof is now covering the first wooden shingles but also conservating the entire wooden building, as can be seen after similar cases of wooden churches from that area destroyed by the moisture from the rains followed by the fungal attacks. The changing of the roof finishing material but the maintenance of the roof geometry and structure could also be undesirable on a heritage building intervention. The original design and first design version propose the wooden shingles roof preserving. In the second design version, the PV solar roof tiles that replace the wooden shingles roof could also be assimilated into the most natural built environment evolution. A similar SWOT method is used in the presentation of the technical and theoretical arguments to sustain the potential of the two design versions for a possible new future intervention.

2.1. The first version: about Identity

David Seamon, in the same text[6], remembered Alexander Christopher's pattern about Identity as "14. identifiable neighborhood". We linked to the "24. Sacred sites" pattern [8]: "… in every region and every town, indeed in every neighborhood, there are special places which have come to symbolize the area and the people's roots there. (...) in some form, they are essential." There is a recommendation to protect "our roots." It is the main objective of this design version to preserve the essential place for the community.

Figure 1. Floor plans worked on drawings after measurements: 1 - The proposed ground floor plan with the reopened veranda access as 1796' initial; 2 - The withdrawn floor plan; 3 - The roof floor plan with the "new" wooden shingles finishing.

Figure 2. Reopened access detailed, the elevation drawings: 1 – the entrance door proposed to reopen, as in 1796 – opening's detail drawing and existing photos; 2 - Southern elevation with the newly reopened access; 3 - Eastern elevation.
Table 1. Evaluation with a similar SWOT method - the first design version

| Strengths | Weaknesses |
|-----------|------------|
| **Technical** | **Technical** |
| - Intervention after ICOMOS's charters, also the vernacular heritage charter [2]; - The preservation of the whole original materials, even the original wooden shingles roof; | - The more difficult maintenance of the wooden shingle roof as the lack of Sustainability; |
| **Theoretical** | **Theoretical** |
| - Assume it as a "sacred space" with "genius-loci," relevant for Place Identity that deserves preservation [6] [8]; - Hundertwasser [5]: "Everyone should be able and have to build and thus be truly responsible for the four walls in which he lives." ignoring the context of Hundertwasser's words; he refers to the building ability traditionally available to unspecialized people technics. | - Augustin Ioan [9]: The sustain that the simplicity and the similarity with a "dwarfism" of some Sacred Space are not real qualities, there is more "sustainable development" in the Romanian vernacular architecture, even that is not a value specifying a sacred space; - Specialized people on his time did not accept Hundertwasser's opinions [5] in the context of his contestation to Adolf Loos's rationalism in architecture. |

| Opportunities | Threats |
|----------------|---------|
| **Technical** | **Technical** |
| - The original wooden shingles roof; - The preserving the immaterial heritage of the wood shingle roof craft; | - Risk of museification; - The lack of Sustainability - the roof material in time could risk the material existence of the whole wooden building; |
| **Theoretical** | **Theoretical** |
| - Baukulture: the local community sustains the traditional wooden church design, the design that is in the execution auction stage. - FutuRESTorive [10]: "Culture and community - Respecting and reviving local identity, wisdom and culture." "While the building is important, let's not forget community (...) human and diversity issues central to sustainability." | - Risk of dissolution for "edification" as a human quality after Francoise Choay[11] with the technologies integration that is not the same as Hundertwasser's [5] building ability: the first is the specialized people skill, last is an inherent one, with the vernacular architecture as a result. |

**Conclusion:** As a traditional restoration work, the main strength is the preservation of Identity linked to heritage value. The heritage is also material as the heritage building and immaterial of the wooden shingle craft. The opportunities and the threats were fewer as the practice has tested it, and the strengths stay very relevant.

2.2. The second version: about Sustainability

![Render images of PV tiles grey color[15] church roof versus existing photos taken in January 2013 from similar positions: 1 – the southern view of the church with the veranda; 2 - the galvanized sheet roof finishing versus PV tiles roof render detail; 3 - north-western view of the church.](image)
Table 2. Evaluation with a similar SWOT method - the second design version

| Strengths | Weaknesses |
|-----------|------------|
| **Technical** | **Technical** |
| - Easier maintenance of the material - PV roof tiles; | - Intervention that is not in concordance with ICOMOS's charters [2]; |
| - To save some parts of the original wooden shingles already hidden under existing metal finishing; | - Similar manufactured products do not support a slope bigger than the ordinary adopted to PV; |
| - Sustainable material and an alternative energy source, a heritage building and an "active" building at the same time; | - For avoiding any condensation is a necessary ventilated space of the backside of the PV; |
| - Possibility of new functionality: a source of alternative energy for the community. | - Lack of visual concordance between the old picture and the new one with the time required to assimilate them by people from the local community; |
| **Theoretical** | **Theoretical** |
| - "creative problem-solving in a regenerative culture" that could achieve in a critical debate [12]. | - Materials visual contrast could create opportune disagreements; |
| - Design not ethical from the traditional/indigenous cultural point of view [12]. | - The actual cost of PV technology. |

| Opportunities | Threats |
|---------------|---------|
| **Technical** | **Technical** |
| - A specific PV solar roof tiles adequate for a heritage building as own loads and very easy to improve on the winter times the snow loads trough a roof defroster system; | - Creating a precedent in PV technology on wooden heritage building: an inadequate intervention with new improper material on a vernacular heritage building could risk even the building heritage value; |
| - A regenerative design achieved in a heritage building - the heritage building vitalization; | - Losing the immaterial heritage of the wooden shingle roof craft; |
| - "Regenerative Sustainability" b poorly implemented in Europe [14]; | - Inadequate after ICOMOS's charters [2] that could lead to the impossibility of receiving the official permit for the intervention; |
| **Theoretical** | **Theoretical** |
| - Francoise Choay [11]: The necessity to sustain Homo Sapiens' edification pieces of knowledge also using new technologies; | - The interaction between two different technologies not tested enough in the local environmental factors could lead to inadequate (condensation risk); |
| - Augustin Ioan [9]: To exceed the "dwarfism quality" of the vernacular Sacre Space and "make it visible" for the community, versus A. M. Dabija' words about some small heritage churches [7]. | - A visual change could decrease the favorable perception of the heritage building over the local community. |
| - FuturRESTorive [10]: "a new culture of sustainability." | **Theoretical** |
| - Heidegger[13]: Nature and, after all, Humanity in a "standing-reserve" form trough Technology (and in more specific terms: to adopt one technology as an automatic answer without absolving any risk). |

**Conclusion:** This second design version could define as a "transition design" between green/sustainable design and "designing regenerative culture" adapted to the local environmental factors and the inhabit people's traditional culture. Or could it be just an improper restoration design after ICOMOS's charter and current quality design practice? As can be seen, there are opportunities and many threats, very similar to any new and not-tested intervention yet. A significant risk is losing identity through this iconic heritage building, and it is tough to assume it, and maybe the most important is the restraint in creating this precedent.

1 Daniel Christian Wahl's [12] "Designing regenerative cultures" book, after his Ph.D. thesis, admitted several concepts like Cameron Tonkinwise "transition design" or some other compatible ideas.
2 Survey results about "Regenerative Sustainability" poorly implemented in Europe [14]: The study was on new buildings or existing ones, and we assumed the PV materials/technology are "emerging" versus "traditional"/"innovative" as studied. "Some of the barriers to implementing emerging materials, technologies, and tools (…) include lack of training, the lack of necessary information, and the higher cost."
3. Results and discussions
It could be a necessity to design a strict framework about the limits of the enlarge the sustainability measures supported by technology. The sustainability targets - an opportunity or a threat to many of Humanity’s values? Is the regenerative design an answer? It is too subjective or, on the contrary, too technical, as the perfectability of the technology’s result, not in all cases desirable. Nevertheless, the second version cloud assures longer life to this landmark of social serenity.

3.1. The second version - the evaluation of the electrical energy produced as BIPV

The numerical values for electrical energy produced with photovoltaic technology without shading will appear evaluated with the Technical University of Cluj-Napoca’ software - TUCN, program validated by comparison with dedicated software (PVsyst 6.8.6 – preliminary design stage[16] / PHPP_V9.6[17] - without DesignPH evaluation). The assessment in all software based on the technical details after PV Solecco Roof Tiles covering 98% of the roof [15] with technical dates as following: tile rated power - 15 W, tile dimensions: 1 - 0.298 m x L - 0.335 m. All 24 PV tiles surfaces noted after the distinct azimuth or the different slope are in Figure 5 and represents incoming dates in all used software. PVsyst 6.8.6 [16] is the dedicated software to photovoltaic technology used in this study case in the stage of ‘preliminary design” that, in the next stages, could evaluate eight distinct roof surfaces (azimuth/angle). However, there are not the PV solar roof tiles specifications in its included providers database. One possible explanation for the result of PVsyst higher energy values is that PVsyst considers the higher performance of PV tile, difference noticed under the distinct incoming dates of the preliminary design stage: the nominal power versus the active area. PHPP 9 [17] is the software dedicated to the “passive house” defined according to the ”Passive House Institute” that only touches the photovoltaic technology with the possibility to define only five distinct solar roof surfaces (azimuth-angle) recommended to use with ”DesignPH” software that could evaluate the shading after the 3D model. TUCN software calculates electrical energy with the PV performance of 15.3% and the other technical dates of PV Solecco Roof Tiles [15], as the tile surface and the tile rated power. The values of solar radiation and ambient temperature in TUCN software were taken from the Typical Meteorological Year (TMY) available for the location site Cojocna/Cluj-Napoca in the TUCN software and PHPP, and "Cluj-Napoca/ Someseni Meteonorm 7.2 station" in PVsyst.

In principle scheme of the energy conversion into a solar PV roof system, considered in the mathematical model, is presented in figure 4.

![Figure 4: Scheme of the PV system in the mathematical model.](image)

The Sun (1) provides solar radiation (2) that is converted by the PV tiles (3) into direct current electricity (4) and by an inverter (5) into alternative current electricity (7) that can be used by the electricity consumers (7).

The mathematical model developed at the Technical University of Cluj-Napoca (TUCN) is calculating the solar position, the angles between the solar radiation and the tilted plane of the PV surfaces, and the different forms of involved energies. The model was already validated in [18-20].

The electric efficiency of the PV collectors ($\eta_{PV}$ [%]) can be calculated by:

$$\eta_{PV} = \eta_{Tref} \left\{1 - \beta_{ref} \left[ T_a - T_{ref} + (T_{NOCT} - T_{aNOCT}) \frac{I_{gt}}{I_{gNOCT}} \right] \right\}$$  \hspace{1cm} (1)

where: $\eta_{Tref} = 15.3 \%$ is the nominal efficiency of the PV panels in reference conditions, at the reference solar radiation and at the reference temperature ($T_{ref} = 298 \text{ K}$) and correspond to the nominal peak power of the PV tiles of 15 W; $\beta_{ref} = 0.004 \text{ °C}^{-1}$ is a coefficient of correction available in the technical leaflet.
of the PV panel; $T_a$ [K] is the ambient temperature; $T_{\text{NOCT}} = 318$ K is the normal operating collector temperature determined in test conditions (ambient temperature $T_{\text{ANOCT}} = 293$ K; global solar radiation $I_{\text{gNOCT}} = 800$ W/m$^2$; wind speed $w = 1$ m/s); $I_{\text{g}}$ [W/m$^2$] is the global radiation normal at the tilted surface of the PV roof surface.

Table 3. Distinct surfaces notation - distinct azimuth/slope, cad drawing in figure 6

| # | Name | Orientation Slope | Azimuth TUCN | PHPP | Pvsyst | Roof surface | Tiles Number |
|---|------|-------------------|-------------|------|--------|--------------|--------------|
| 1 | 1-0 | S                 | 53.56       | 346.54 | 166.54 | -13.46       | 79.16        | 792          |
| 2 | 1-1 | S                 | 50.33       | 346.54 | 166.54 | -13.46       | 24.51        | 245          |
| 3 | 1-2 | S                 | 77.03       | 346.54 | 166.54 | -13.46       | 4.96         | 49           |
| 4 | 1-3 | S                 | 56.11       | 346.54 | 166.54 | -13.46       | 11.34        | 113          |
| 5 | 1-4 | S                 | 40          | 346.54 | 166.54 | -13.46       | 5.56         | 55           |
| 6 | 1-5 | SE                | 61.96       | 310.73 | 130.73 | -49.27       | 6.83         | 68           |
| 7 | 2-0 | N                 | 59          | 166.54 | 346.54 | 166.54       | 84.92        | 850          |
| 8 | 2-2 | N                 | 77.03       | 166.54 | 346.54 | 166.54       | 4.96         | 49           |
| 9 | 2-3 | N                 | 56.41       | 166.54 | 346.54 | 166.54       | 11.01        | 110          |
| 10| 2-4 | N                 | 40          | 166.54 | 346.54 | 166.54       | 5.56         | 55           |
| 11| 2-5 | NE                | 61.41       | 161.37 | 341.37 | 161.37       | 7.30         | 73           |
| 12| 3-0 | E                 | 63          | 256.54 | 76.54  | -103.46      | 6.42         | 64           |
| 13| 3-1 | E                 | 83.5        | 256.54 | 76.54  | -103.46      | 17.13        | 171          |
| 14| 3-2 | E                 | 77.03       | 256.54 | 76.54  | -103.46      | 4.96         | 49           |
| 15| 4-1 | V                 | 75.6        | 76.54  | 256.54 | 76.54        | 21.97        | 220          |
| 16| 4-2 | V                 | 77.03       | 76.54  | 256.54 | 76.54        | 4.96         | 49           |
| 17| 1-6 | S                 | 71.56       | 346.54 | 166.54 | -13.46       | 2.09         | 20           |
| 18| 2-6 | N                 | 71.56       | 166.54 | 346.54 | 166.54       | 2.09         | 20           |
| 19| 3-6 | E                 | 71.56       | 256.54 | 76.54  | -103.46      | 2.09         | 20           |
| 20| 4-6 | V                 | 71.56       | 76.54  | 256.54 | 76.54        | 2.09         | 20           |
| 21| 1-7 | S                 | 90          | 346.54 | 166.54 | -13.46       | 4.21         | 42           |
| 22| 2-7 | N                 | 90          | 166.54 | 346.54 | 166.54       | 4.21         | 42           |
| 23| 3-7 | E                 | 90          | 256.54 | 76.54  | -103.46      | 2.50         | 25           |

3.2. Results - Preliminary investigation without considering shading

![Figure 5](image.png)

Figure 5. The roof floor plan with PV tiles finishing – the surfaces noted after the distinct azimuth or the different slope: the surfaces 1-0-1, 1-1-1, 2-0-1 considered “sunny” areas of the roof are included in 1-0, 1-1, 2-0 surfaces and are detailed in “2.3.2 Results - Influence of shading”/Table 5.

We used the original software developed in the Technical University of Cluj-Napoca, where the technical parameters are according to technical sheets available for PV tiles, as incoming configurable dates. The calculations are performed under the conditions of PV tile performance-15.3% that
corresponds to a maximum power of 15W/tile. That allows the correct evaluation of PV electrical energy production validated by comparison with the results provided by two commercial software in table 4.

Table 4. The numerical values for electrical energy: PVsyst [16] / PHPP [17] / TUCN, with the technical dates after PV Solecco Roof Tiles [15]

| 98% of the roof surface covered [15] | PVsyst - incoming dates | PHPP - without shading | TUCN no shading |
|--------------------------------------|--------------------------|------------------------|----------------|
| m² | P (W) | S (mp) | KWh/year | KWh/year | KWh/year | kWh/year |
| 77.47 | 776 | 11640 | 14723 | 15664 | 13598 | 2254 | 13858 |
| 23.96 | 240 | 3600 | 4596 | 4894 | 4254 | 795 | 4357 |
| 4.79 | 48 | 720 | 830 | 830 | 710 | 710 | 697 |
| 10.98 | 110 | 1650 | 2060 | 2193 | 1907 | 0 | 1935 |
| 5.29 | 53 | 795 | 1091 | 1091 | 956 | 0 | 997 |
| 6.59 | 66 | 990 | 1119 | 1191 | 1024 | 250 | 1156 |
| 83.16 | 833 | 12495 | 5923 | 6308 | 5496 | 2707 | 5672 |
| 4.79 | 48 | 720 | 244 | 244 | 241 | 241 | 239 |
| 10.68 | 107 | 1605 | 795 | 846 | 736 | 0 | 770 |
| 5.29 | 53 | 795 | 547 | 547 | 475 | 0 | 531 |
| 7.09 | 71 | 1065 | 537 | 537 | 463 | 224 | 456 |
| 6.19 | 62 | 930 | 759 | 808 | 678 | 218 | 867 |
| 16.67 | 167 | 2505 | 1679 | 1788 | 1617 | 1617 | 1853 |
| 4.79 | 48 | 720 | 552 | 552 | 578 | 578 | 579 |
| 21.46 | 215 | 3225 | 2893 | 3080 | 2574 | 2574 | 1813 |
| 4.79 | 48 | 720 | 637 | 703 | 573 | 573 | 396 |
| 1.90 | 19 | 285 | 346 | 346 | 301 | 301 | 294 |
| 1.90 | 19 | 285 | 121 | 121 | 104 | 104 | 103 |
| 1.90 | 19 | 285 | 231 | 231 | 195 | 195 | 244 |
| 1.90 | 19 | 285 | 283 | 283 | 240 | 240 | 171 |
| 4.09 | 41 | 615 | 604 | 604 | 423 | 423 | 488 |
| 4.09 | 41 | 615 | 203 | 203 | 521 | 521 | 163 |
| 2.40 | 24 | 360 | 237 | 237 | 101 | 101 | 242 |
| 2.40 | 24 | 360 | 294 | 294 | 201 | 201 | 156 |
| TOTAL | | | 41304 | 43595 | 37966 | 14827 | 38037 |

3.3. Results - Influence of shading

The study of PV roof electricity production should take into account the shading effect, because large numbers of PV tiles are connected into series and in these conditions even if a reduced number of tiles are shaded the PV electricity production of the whole group of tiles drops dramatically, and the presence of the tower on the top of the roof produces much shade. The shade influence was investigated with the TUCN program for the most productive surfaces without shading, respectively, the surfaces 1-0; 1-1 and 2-0. These three surfaces produce 62.8 % of the electricity, without considering shading. For each of the three surfaces, the tiles in the sunniest areas (1-0-1; 1-1-1 and 2-0-1) were considered connected separately from the other tiles to increase the electricity production, as suggested in figure 6. The considered numbers of the "sunny PV tiles" and the electricity production for each of the three surfaces (1-0-1, 1-1-1, 2-0-1), under shading conditions, are presented in figure 5 and table 5.
Table 5. The numbers of PV tiles and the PV production for the "sunny" surfaces

| Surface | No. of tiles | PV production with shading [kWh/year] | The fraction of PV production without shading |
|---------|--------------|---------------------------------------|-------------------------------------------|
| 1-0-1   | 589          | 6224                                  | 44.9 %                                    |
| 1-1-1   | 165          | 1768                                  | 40.6 %                                    |
| 2-0-1   | 627          | 2154                                  | 38.0 %                                    |

These calculations reveal that for the investigated roof, the PV electricity production under shading conditions represents about 40 % of the estimated PV electricity production of the corresponding surfaces without shading. For the other surfaces, the influence of shading is estimated to be even higher, because not only the tower but also the building itself produce shading on several surfaces, excepting 1-2; 2-2; 3-2; 4-2; 1-7; 2-7; 3-7 and 4-7, that will still produce together 2960 kWh, representing 7.8 % of the PV electricity production, without considering shading.

4. Conclusions
The research started in the nowadays context from the sustainability area, and one question that appears natural was about how close to regenerative design can achieve through restoration works. In the same context, heritage building values sustain the potential of a regenerative design that could support a regenerative culture. However, never without the Identity that is represented by heritage buildings.

Acknowledgments
We address many acknowledgments to colleagues from the Aqua Prociv Proiect, Cluj-Napoca, Romania, also to the experts whom the company has collaborated in this restoration project. Are noticed as essentials the professors in architecture and restoration experts, Adrian Matei and Virgil Pop, the art history specialists between them professor Nicolae Sabau, and the wooden biology expert, Livia Bucsa. Are necessary the acknowledgments to the members of the Zonal Commission of Historical Monuments for their so needed consultancy and feedback. Were signifiant the piece of knowledge and the support from COST Action RESTORE - Rethinking Sustainability towards a Regenerative Economy - CA16114, supported by COST - European Cooperation in Science and Technology. We also admit the importance of the support from afferent companies for the PV dedicated software, PVsyst - the educational license [16] and Romanian Organisation affiliated iPHA – "International Passive House Association" – PHPP [17].

References
[1] National Register of Historic Monuments in Cluj County, Romania, code: CJ-II-m-B-07573, 1076 / p. 1018, http://www.cultura.ro/sites/default/files/inline-files/LMI-CJ.pdf; (accessed: February 2020);
[2] "Charter on the built vernacular heritage," ICOMOS, Mexico, October 1999, https://www.icomos.org/charters/vernacular_e.pdf; (accessed: February 2020)
[3] "Adaptive re-use of the built heritage: preserving and enhancing the values of our built heritage for future generations," adopted on 23 November 2018, Leeuwarden, Netherland, (accessed: June 2019); https://www.ace-cae.eu/uploads/tx_jidocumentsview/LEEUWARDEN_STATEMENT_FINAL_EN-NEW.pdf;
[4] Sabau, Nicolae, "Anuarul Institutului de Istorie si Arheologie – vol. XXII", Editura Academiei Republicii Socialiste Romania, pp. 368-385, p. 387, 1979; upgraded in the historical survey: Sabau, Nicolae, Rusu, Ioana, "Studiul istorico-arhitectural, Biserica de lemn "Intrarea in biserica a Maicii Domnului," Cojocna, judeul Cluj," February 2014;
[5] Hirsch, Andreas, "Hundertwasser – The art of the green path," Kunst Haus Wien, Museum Hundertwasser, Prestel, "Mouldiness Manifesto against rationalism in Architecture" - p. 125, pp. 198-199, 2011;
[6] Seamon, David, "Place, Place Identity, and phenomenology: a triadic Interpretation based on J.G.
Bennett's Systematics, "The role of place identity in perception, understanding, and design built environment, Hernan Casakin and Fatima Bernardo (Eds), Bentham Science Publishers, pp. 3-21, pp.16-17, 2012;

[7] Dabija, Ana-Maria, "Roofing in Romania: lessons from the past," "Roofing-the industry voice," vol. 8, issue. 4, no. July-August, 2017, conference paper, International Conference on Building Envelope Systems and Technologies (ICBEST), Turkey, Istanbul, pp. 36-44, p. 41 2017;

[8] Alexander, C., Ishikawa, S., Silverstein, M., with Jacobson, M., Fiksdahl-King, Angel, S. "A pattern language – Towns, Buildings, Constructions," Oxford University Press, New York, pp. 131-134, 1977;

[9] Ioan, Augustin, "Retrofuturism – spatul sacru azi," Editura Paideia, Bucuresti, pp. 271-290, 2010;

[10] Brown, Martin, "FutuREstorative – Working towards a new sustainability," "The new sustainability standards": pp. 115-136, RIBA Publishing, p. 131, p. 134, 2016;

[11] Choay, Francoise, "Patrimoniul la rascruce - Antologie de lupta," Ed. Ozalid, Bucuresti, pp.48-49, 2014;

[12] Wahl, Daniel Christian, "Designing regenerative cultures," Triarchy Press, Axminster, England, with International Futures Forum, Aberdour, Scotland, p.62, pp. 130-132, 2016;

[13] Heidegger, Martin, Basic Writings, David Farrell Krell (ed.), New York: Harper Collins, "The Question Concerning Technique", pp. 311-341, pp. 320-329, 1993;

[14] Peretti, G., Druhmann C. K., Bleiziffer, J., Brown, M., Pizarro, R.C., Merino, M. R., Kontovourkis, O., Gremmelspacher, J. M., Nonon, S., Purs, I, Sáez, P. S., Rizvanolli, B., V., "Regenerative Construction and Operation - Bridging the gap between design and construction, following a Life Cycle Approach consisting of practical approaches for procurement, construction, operation, and future life"; COST ACTION CA16114 RESTORE, WG 3 report: Regenerative Construction and Operation, p.69, pp. 79-80 2019;

[15] PV Solecco Roof Tiles, http://www.soleccosolar.com/custom-build-renovation/ (accessed: March 2020);

[16] PVsyst 6.8.6, https://www.pvsyst.com/ (accessed: March 2020);

[17] PHPP V9.6, https://passivehouse.com/04_phpp/04_phpp.htm#PH9 (accessed: March 2020);

[18] Unguresan P.V., Porumb R.A., Petreus D., Pocola A.G., Pop O.G., Balan M.C., "Orientation of Facades for Active Solar Energy Applications in Different Climatic Conditions," J. Energy Eng. 143(6) (2017): 04017059;

[19] Unguresan P.V., Petreus D., Pocola A.G., Balan M.C, "Potential of solar ORC and PV systems to provide electricity under Romanian climatic conditions," Energy Proc. 85 (2016) 584-593;

[20] Petreus, D., Balan, M.C., Pop, O.G, Etz, R., Patrau, T., "Evaluation of the PV energy production determined by measurements, simulation and analytical calculations," E3S Web of Conferences 85 (2019) pp. 1-8.