FEASIBILITY STUDY FOR IMPLEMENTING ENERGY STORAGES IN BRACAK (HR)

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FEASIBILITY STUDY FOR IMPLEMENTING ENERGY STORAGES IN BRACAK (HR)

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Content

1. Introduction

In course of the project Store4HUC, a feasibility study will be carried out for every pilot region of 4 countries (IT, AT, CRO, SI). A feasibility study is simply an assessment of the practicality of a proposed plan or project. It takes all relevant factors into account—including economic, technical, legal, and scheduling considerations—to ascertain the likelihood of completing the project successfully and is therefore used to discern the pros and cons of undertaking a project before they invest a lot of time and money into it. As the name implies, the study deals with the question, if the project/pilot is feasible or not. The main goals can be defined as follows[1]:

- To understand thoroughly all aspects of a project, concept, or plan;
- To become aware of any potential problems that could occur while implementing the project;
- To determine if, after considering all significant factors, the project is viable—that is, worth undertaking.

This document will deal with the feasibility study of the pilot in Bracak (HR). The feasibility studies should outline the constraints and solutions from various aspects (technical, economic, monumental protection, status quo of HUC, ensure further implementation actions, etc.) to implement the pilot at the historical sites. The main target of the study is to enable a decision making about the pilot ("go" or "no-go" decision). A further target is to inform all relevant stakeholders and to get a first feedback from them. In contrast to the pre-investment concept, which will be carried out in D.T.2.1.3, the feasibility study will focus on first rough analysis and plausibility checks. If the feasibility study leads to a positive result, the pre-investment-concept will be carried out as next step, where all specifications of the pilot for the application of the building permit will be specified. Therefore, the pre-investment-concept has to be much more detailed than the feasibility study, but nevertheless all major impacts are already considered in the feasibility study, to enable the evaluation of the pilot.

To clarify the vision of the pilot, the mission statements according to the UNESCO-rules/conservation rules, the sustainability criteria, the environmental friendliness, the moderns and the legislation are defined in the second chapter. Based on the mission statements, strategies, targets and operative actions are deduced for the pilot. To classify the meaning of the pilot for the proposed HUC, the status quo is described in chapter three. Dealing with questions like: "Are there already any other best practice examples on RES and EE?", "How great is the willingness of the city/region for innovations like this?" or "What are the constraints, benefits, changes and barriers?", and so on,

In chapter four, the main factors for the assessment of the pilot are discussed. Starting with the technical specifications of the pilot like "what is planned?", "which type of storage will be used?"," why is this type of storage considered as the best option?", "what other installations are planned?", etc. From the economic perspective, the estimated costs (investment, operation) as well as the expected savings are explained. A first finance plan shows how to pilot will be financed and the next steps are planned. Moreover, a SWOT analysis was carried out, the show the strengths, weaknesses, opportunities and threats, of the pilot plant. Based on this information, the assessment of the practicality of a proposed pilot can by carried out.

[1]Kenton, Will (11.08.2019): Feasibility Study. URL: "https://www.investopedia.com/terms/f/feasibility-study.asp [10.10.2019].

2. Mission Statements

The aim of the Bracak pilot project is the implementation of a central battery (bank) system, installation of photovoltaic system, and integration of it to advanced Energy management system, which include server build-up and open two-way database for optimal coordination of the energy systems with the possibility of prediction and cost management in the Bracak Manor. Bracak Manor is already equipped with wood pellets boiler for heating, micro CHP for hot water and power production during summer, air-water heat pump system for cooling and heating in transitional periods, wall insulation on the inside and energy efficient windows and doors, efficient lighting system, HVAC system, central BMS for monitoring of heating, cooling and energy consumption, rainwater harvesting for irrigation of green areas and wastewater treatment as well as electric vehicle charging station. The already existing systems will be combined with the new ones through an advanced energy management ICT system that will be built on top of the already existing central monitoring system as a coordination service that optimally exploits all different available assets. The introduced energy management system will inherit the preview project - 3Smart (UNIZG FER). Also, because the building is under cultural heritage protection the Conservation Office in Krapina will be involved in all stages of planning and implementation of the project activities. The battery storage and photovoltaic system as low carbon energy source will provide good showcase to the local authorities which will benefit in terms of improved energy efficiency and increased use of renewable energy sources and lower energy costs. Bracak pilot project should serve as an innovative best-practice example over the next years and as a model for simplified technical and economic implementation in protected historic monuments and landscapes and lead to a significant increase in the proportion of renewable energy sources in historic urban centres.

2.1. According to european and international guidelines and recommendations on conservation and rehabilitation of historic monuments and sites

Goals and actions to be achieved by this project are in accordance and in respect with key ethical and technical guidance and recommendations on heritage interventions brought by most relevant European and international institutions that deal with heritage protection and conservation such as UNESCO, European Commission, Architects' Council of Europe and above all ICOMOS - International Council on Monuments and Sites, only global non-government organisation dedicated to promoting the theory, methodology, and scientific techniques to the conservation of heritage. All those international charters for the conservation and restoration of monuments, starting from *The Venice Charter (1964)* up to more recent *The Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas (2011)*, *The Paris Declaration On heritage as a driver of development (2011)* and most recent documents delivered in the framework of the European Year of Cultural Heritage 2018; *Leeuwarden declaration on adaptive re-use of the built heritage: preserving and enhancing the values of our built heritage for future generations and European Quality Principles for Cultural Heritage Interventions* insist on following:

- Investments in cultural heritage that are bringing benefits across the four areas of sustainable development: economy, culture, society and the environment;
- re-use of heritage monuments that will make them sustainable and comfortable for modern use and in that way will bring to prolongation of their life;
- on multidisciplinary- usage of knowledge and skills form different disciplines;
- on using a new solution to emphasise and strengthen cultural values and give added value to a monument or site;

- on bringing new functions to heritage monument that respond to community needs;
- on reuse of heritage sites that can generate new social dynamics in their surrounding areas and thereby contribute to urban regeneration;
- with smart renovation and transformation heritage sites can find new, mixed or extended uses.

2.2. According to sustainability criteria

Bracak pilot project is entirely in line with the Krapina-Zagorje County Development Strategy for the period up to 20202 Krapina-Zagorje County Energy Efficiency Action Plan 2017-20193, Krapina-Zagorje County Annual Energy Efficiency Plan for 20194.The main points of these strategies, and plans are briefly summarised below:

- Krapina-Zagorje County Development Strategy for the period up to 2020

The Krapina-Zagorje County has set itself the goal of renovation of buildings under cultural protection with increased usage of energy efficiency measures and use of energy from renewable energy sources (measure 3.2.1.). The stated goal is in line with the objectives of the Europe 2020 strategy, which are to encourage the use of renewable sources in electricity production. It also coincides with the objective of encouraging the use of RES and energy efficiency and the promotion of projects. Renewable energy sources and energy efficiency are the main pillars of energy sustainable development and are an indicator of the level of technological development and energy awareness that affect the economic, environmental and social development of the whole society. Encouraging and promoting the active use of renewable energy systems would increase knowledge and awareness on the one hand, which directly influences the change of thinking and attitudes of the local population, and on the other hand directly contributes to increasing the share of energy from renewable energy sources.

- Krapina-Zagorje County Energy Efficiency Action Plan 2017-2019

The Krpaina-Zagorje County within Energy Efficiency Action Plan has recognized the importance of energy efficiency, and in 2017 renovated the Bracak Manor with support of the Ministry of Regional Development and EU Funds and Environmental Protection and Energy Efficiency Fund (EPEEF) and established the Bracak Energy Center as a regional center of excellence and knowledge for energy efficiency and renewable energy. The goal of the Krapina-Zagorje County in the future is to enable further strengthening of competitiveness and realization of development potentials through active implementation of projects primarily energy efficiency, renewable energy sources and environmental protection, having a key role in the sustainable development of society.

- Krapina-Zagorje County Annual Energy Efficiency Plan for 2019

The Krpaina-Zagorje County has set itself an energy efficiency commitment to achieve the 20% primary energy savings target at EU level by 2020. The EU's climate and energy policy for the period 2020 to 2030 has set new ambitious targets for increasing energy savings of at least 27% bearing in mind the 30% energy savings target at EU level. The European Union also sets a long-term goal of reducing CO2 emissions from the construction sector by 80-95% by 2050. Monitoring the implementation of the Annual Plan involves monitoring energy savings by identifying a reduction in energy consumption relative to the state before implementing energy efficiency improvement measures.

[2] Strategija razvoja Krapinsko zagorske Županije do 2020. godine http://www.kzz.hr/sadrzaj/dokumenti/strategija-razvoja-2020/KZZ_Strategija_Razvoja_do_2020_godine.pdf (11.12.2019.)

[3] Akcijski plan energetske učinkovitosti Krpainsko-zagorske županije za razdoblje 2017.-2019. Godine http://www.kzz.hr/sadrzaj/dokumenti/programi-planovi-enu/KZZ_Akcijski_plan_EnU_2017_2019.pdf (11.12.2019.)

[4] Godnišnji plan energetske učinkovitosti Krapinsko-zagorske županije za 2019. Godinu http://www.kzz.hr/sadrzaj/dokumenti/programi-planovi-enu/KZZ_Godisnji_plan_EnU_2019.pdf (11.12.2019.)

Also, the storage and photovoltaic system in combination with advanced energy management system will provide good showcase to the local authorities which will benefit in sense of improved energy efficiency and increased use of renewable energy sources and lower energy costs. The energy management tool will enable to monitor all features that proof the effectiveness and sustainability of the pilot installations.

2.3. According to environmental friendliness

Up to 80% of total energy consumption in the EU is attributed to urban areas, mostly situated with historical urban centres (HUC). Store4HUC has taken up this challenge and proposes a viable forward-looking approach aiming to maximise synergies, knowhow transfer, follow specific objectives given hereafter and to allow mutual learning between HUC in CE.

With the installation of battery system and photovoltaic system as a renewable energy source in combination with advanced Energy management system Bracak Pilot project will directly contribute to environmental protection in terms of reduced CO_2 emissions and increased usage of renewable energy sources. Energy management system as a smart solution for optimal coordination of the energy systems will also reduce energy consumption for whole building because of its planned possibility of prediction and cost management.

With the implementation of this pilot project, it is planned to save up to 24.470 kWh of electricity per year in total and reduce CO_2 emissions by up to 5,7 tonnes. The exact calculation (in total and per metering point) of the savings will be calculated in the pre-investment study. The implementation of this Bracak pilot project will give local authorities the right arguments to promote investments in sustainable urban energy solutions in Historical urban centres with positive effects on the environment and health of the local population in the city centres.

2.4. According to modernes / state-of-the-art

Given the status of the Energy centre Bracak as a protected (by national laws) cultural heritage- options for implementing the pilot action were limited (note: nothing that changes a visual appearance of the building itself is not doable). Therefore, as an acceptable solution - pilot project in Bracak should consist from building a **steel/aluminium canopy** at the Energy centre Bracak parking lot (*carport*) where **solar photovoltaic (PV) system** will be installed on top. Electrical energy produced on-site will be used in Energy centre and all the surplus will be stored within **battery energy storage system (BESS)** also installed in this pilot action.

One of the most remarkable trends in energy economics over the last 50 years is the tremendous reduction in solar photovoltaic (PV) prices- from 1970 to this day the prices are 1000 times lower which marks the PV projects as commercially viable[5]. Analysis of the electrical energy consumption in Energy centre Bracak, which has 3 separate metering points for electricity (basement + first floor, ground floor and attic), showed the potential for (at least) 7 kW PV system per metering point (21 kWp photovoltaic system in total), especially if using monocrystalline panels whose production should be manageable individually with microinverter technology. Microinverters are suitable for this pilot action because of the location characteristics as well, given the shadowing which is occurring on the parking lot during the day. With regular string inverter the production of PV system is limited according to the lowest productive module - with microinverters the production of electrical energy is individual, based on each module separately which enhances the overall production. Also, the advantage of microinverters is that the system is easy to

[5] Wolfram C. (2019). *What Drove Solar PV Price Reductions*, URL: https://energyathaas.wordpress.com/2019/09/09/what-drove-solar-pv-price-reductions/

upgrade (with more PV modules) in the future not to mention the standard guarantee period of 25 years for microinverter technology as well as for PV panels.

Energy storage, on the other hand, is recognised as a key element in modern energy supply chain. This is mainly because it can enhance grid stability, increase penetration of renewable energy resources, improve the efficiency of energy systems, conserve fossil energy resources and reduce environmental impact of energy generation. Although there are many energy storage technologies already reviewed in the literature, these technologies are currently at different levels of technological maturity with a few already proven for commercial scale application[6].

Energy storage system relevant to the pilot project Bracak is the one which refers to a process of converting electrical energy into a form that can be stored for converting back to electrical energy when needed. Such a process enables electricity to be produced at times of either low demand, low generation cost or from intermittent energy sources and to be used at times of high demand, high generation cost or when no other generation means is available[7].

Most common way to store electrical energy is to use BESS. There are many types of BESS but mostly two can be seen in real life application in Croatia - lithium-ion and lead acid technology. In recent years, many issues regarding the disposal of toxic waste are surrounding the BESS industry so addressing the battery end-of-life issues is industry top priority. Given the role of Energy center Bracak as a front-runner in using of new (emerging) technologies - ecologically acceptable BESS is the most logical option to implement.

Energy management of the versatile energy systems in the Bračak Manor including heating, cooling, energy production and storage will allow to investigate what are the economically and ecologically most favourable technology mixes on historical sites. The knowledge of real-time energy management of UNIZGFER will be combined with expertise of other partners in terms of necessary conditions for installation at HUC and sizing. Existing BMS system will be reconfigured and upgraded for integration with ICT energy management system. It will inherit the developments from Interreg Danube 3Smart project in terms of modular energy management of buildings that is coordinated with electricity grid management. As in 3Smart, it will consist of modules of prediction and estimation, predictive cost optimization and interface towards the automation equipment in the building whereas this structure will be repeated in layers of (i) comfort control in zones, (ii) central HVAC system and (iii) building microgrid with included batteries and PV system. 3Smart modules will be adapted to the historical building context.

2.5. According to legislation

The Europe 2020 strategy aims to ensure that EU becomes a smart, sustainable and inclusive economy. Cities host 68% of EU population, generate around 80% of the EU's GDP, and are also responsible for 70% of energy consumption and 75% of CO_2 emission. They therefore play a key role in achieving the 2020 targets. Historic buildings and areas are often excluded from technological and sustainable development due to the strict and complex legislative and planning framework. Additionally, their exclusion from the European Directive (2002/91/EC), national policies and obligations towards energy efficiency and renewable energy, often holds them back from any dynamic development and technological innovation. Still some regional strategies support such actions. In Croatia different cities have developed or are developing Smart city strategies and these support the innovative approaches to energy management if proven economically viable. Store4HUC aims to overcome barriers to the adoption of energy efficient technologies and RES, influence policy by providing the recommendations and to promote innovation in the area of storage facilities and related energy management in HUC.

[6]Aneke, M., & Wang, M. (2016). *Energy storage technologies and real life applications – A state of the art review. Applied* Energy, 179, 350–377. doi:10.1016/j.apenergy.2016.06.097

[7] Żygadło, Monika & Kotowski, Jerzy & Oko, Jacek. (2018). *Green computing and energy storage systems*. E3S Web of Conferences. 44. 00202. 10.1051/e3sconf/20184400202.

By joining the European Union, Croatia has committed itself to increasing energy efficiency in order to achieve the goal of saving 20% of primary energy consumption at EU level by 2020. The EU's climate and energy policy for the period from 2020 to 2030 has set new ambitious targets for increasing energy savings of at least 27%, bearing in mind the 30% energy savings target at EU level. The European Union has also set a long-term goal of reducing CO_2 emissions from the construction sector by 80-95% by 2050. In order to achieve this basic objective, it is necessary to ensure the implementation of energy efficiency measures at all levels: national, regional and local. The Bracak pilot project will be in line with all legislative frameworks of the Republic of Croatia such as:

- Croatian Energy Efficiency Act (OG 127/2014, 116/18)[8];
- Croatian Construction Act (OG 153/13, 20/17, 39/19)[9];
- Croatian Law on the Protection and Preservation of Cultural Property (OG 69/99, 151/03, 157/03, 100/04, 87/09, 88/10, 61/11, 25/12, 136/12, 157/13, 152/14, 98/15, 44/17, 90/18)[10];
- Croatian Energy Development Strategy[11];
- Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia[12];
- National Public Sector Building Renovation Program 2016-2020[13];
- Fourth National Energy Efficiency Action Plan for The Period From 2017 to 2019[14];
- Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia[15].

[8]Croatian Energy Efficiency Act https://www.zakon.hr/z/747/Zakon-o-energetskoj-u%C4%8Dinkovitosti [December 2019]

[9]Croatian Construction Act https://www.zakon.hr/z/690/Zakon-o-gradnji [December 2019]

[10]Croatian Law on the Protection and Preservation of Cultural Property https://www.zakon.hr/z/340/Zakon-o-za%C5%A1titi-i-o%C4%8Duvanju-kulturnih-dobara [December 2019]]

[11]Croatian Energy Development Strategy http://oie.mingo.hr/UserDocsImages/zakonski%20i%20drugi%20propisi/a)energetika%20opcenito/strategija%20energetskog%20razvoja%20rh/NN%20130_2009.pdf

[12]Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia https://ec.europa.eu/energy/sites/ener/files/HR-Art4BuildingStrategy_en.pdf

[13]National Public Sector Building Renovation Program 2016-2020, available at: https://narodne-novine.nn.hr/clanci/sluzbeni/2017_03_22_508.html [December 2017]

[14]Fourth National Energy Efficiency Action Plan for The Period From 2017 to 2019 https://ec.europa.eu/energy/sites/ener/files/hr_neeap_2017_en.pdf

[15]Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia https://ec.europa.eu/energy/sites/ener/files/HR-Art4BuildingStrategy_en.pdf

3. Status quo of the proposed HUC

The recently renovated Bracak Manor is already equipped with wood pellets boiler for heating, micro CHP for hot water and power production during summer, air-water heat pump system for cooling and heating in transitional periods, wall insulation on the inside and energy efficient windows and doors, efficient lighting system, HVAC system, advanced central BMS for monitoring of heating, cooling and energy consumption, rainwater harvesting for irrigation of green areas and wastewater treatment as well as electric vehicle charging station. Within the Bracak pilot project it is planned to add photovoltaic system and battery storage to it. The already existing systems will be combined with the new ones through an advanced energy management ICT system as a coordination service that optimally exploits different available assets. The introduced energy management system will inherit the preview projects (3Smart).

Energy management of the versatile energy systems in the Bracak Manor including heating, cooling, energy production and storage will allow to investigate what are the economically and ecologically most favourable technology mixes on historical sites. Existing BMS system will be upgraded for integration with ICT energy management system. It will inherit the developments from Interreg Danube 3Smart project in terms of modular energy management of buildings that is coordinated with electricity grid management. As in 3Smart, it will consist of modules of prediction and estimation, predictive cost optimization and interface towards the automation equipment in the building whereas this structure will be repeated in layers. The last renovation of Bracak Castle was in 2017 when the building was completely renovated to the highest energy efficiency standards and all the conservation conditions were respected during the reconstruction.

In Croatia there are very few examples of good practice, but as an example is recognized Spiritual-Educational Center Mary's Court near Zapresic, and Bracak Manor which is the pilot building in Store4HUC project.

Figure 1: Bračak Manor (Energy Centre Bračak)

Source: REGEA 2019

4. Short specification / description of the pilot

In this chapter, the main factors for the assessment of the pilot are discussed. Starting with the technical specifications of the pilot like “what is planned?”, “which type of storage will be used?”,” why is this type of storage considered as the best option?”, “what other installations are planned?”, etc. From the economic perspective, the estimated costs (investment, operation) as well as the expected savings are explained. A first finance plan shows how to pilot will be financed and the next steps are planned. Moreover, a SWOT analysis was carried out, the show the strengths, weaknesses, opportunities and threats, of the pilot plant. Based on this information, the assessment of the practicality of a proposed pilot can by carried out.

4.1. Technical specification

As briefly mentioned in Chapter 2.4 - pilot action involves construction works on carport solution with solar photovoltaic (PV) system installed on top and installation of battery energy storage system (BESS) in the Energy centre Bracak.

The works should be carried out with following technical specifications in mind:

CARPORT WITH PV SYSTEM INSTALLED

- Construction of a steel/aluminium canopy/ies of a size sufficient to cover at least nine parking spaces (6m x 7m x 3), with slope oriented towards SE;
- At least 21 kWp of monocrystalline PV modules installed on top of the canopy/ies with microinverters for each module (power of microinverters is equal to the power of modules);
- overall, minimum of 70 installed PV modules on site (minimum 300Wp/module).

BATTERY ENERGY STORAGE SYSTEM (BESS)

- system needs to be easy-to manage while at the same time- user need to have control of the input/output power of the BESS (smart solution responsive to external factors & should recognize the right time to use energy from the storage), HVAC systems in the building, etc.;
- no toxic materials in the BESS structure;
- 100% deep discharge option (BESS can be completely out of energy without doing damage to the structure);
- at least 4500 life cycles at 80% DOD (depth of discharge);
- 2,0-5,0 kWh plug&play packages available (all-in-one solution- battery, inverter, managing system), overall capacity of up to 15,0 kWh;
- over 25 years life span.

ENERGY MANAGEMENT SYSTEM (EMS)

Already existing systems in the building will be combined with the a newly installed photovoltaic (PV) system and battery energy storage system (BESS) through advanced and smart energy management ICT system. Existing central monitoring system must be upgraded and reconfigured to create coordination service that optimally exploits different available assets. With this system, it will be possible to monitor all data such as: current electricity production, battery charge, current energy consumption and all other data from the HVAC system and the various sensors in the building in order to maximise energy efficiency.

Also, Energy management system it will inherit the 3Smart project concept which will enable smart management of production, consumption and energy storage.

4.2. Economical specification

Economical parameters with **foreseen** costs, according to preferred technical specifications described in previous chapter, are shown in the table below.

Table 1: Economical specification

Part	Investment cost (EUR) (VAT included)	Operating cost/year (EUR)* (VAT included)
Aluminium/steel carport	12.000,00	-
PV system	30.000,00	400,00
Battery energy storage system	12.000,00	250,00
Energy management system	35.000,00	300,00
Overall	89.000,00	950,00

**operating costs imply the costs of insurance and regular maintenance, if applicable*

Financial savings, as a result of the installation of PV&BESS system, are foreseen at around 3.400,00 EUR per year.

4.3. SWOT Analysis

Analysis of the strengths, weaknesses, opportunities and threats of Bracak (HR) pilot

Strengths	Weaknesses
- Increased efficiency (because of advanced Energy management system) - Primary energy savings - Lower pollutant emissions - Efficient battery storage technology	- Higher planning costs due to implementation in a HUC - Higher investment costs due to implementation in a HUC while introducing ecologically acceptable technical solutions - Special solutions due to implementation in a HUC
Opportunities	**Threats**
- Best-practice in terms of implementing innovative (ecologically acceptable) energy storage system in HUCs - Best-practice in terms of implementing photovoltaic system and carport solution - Lower electricity bills - Reduced peak demand for electricity - Increasing energy efficiency and share of RES of HUCs	- Additional permits due to cultural heritage protection laws - Public procurement procedure

4.4. Financing plan

Table 2 shows an indicative cost breakdown of the planned measures.

Table 2. Estimated costs of the planned measures

Cost position	Costs [€]
1 Photovoltaic System (21kWp; 3x7kWp), components and installation	30,000
2 Battery energy storage systems 3x 2,0-5,0kWh, plug&play	12,000
3 Carport, components and construction	12,000
4 Energy management integration costs	35,000
5 Main Project Design /Technical Documentation	10,000
6 Installations supervision	5,000
Total incl. VAT	104,000

4.5. Legal framework conditions

Bracak Castle (Kulmer) is registered in the Register of Cultural Property of the Republic of Croatia - List of protected cultural property under number Z-4019 and is subject to the provisions of the Law on protection and preservation of cultural property as well as other regulations related to cultural heritage. The HUCs in Croatia is governed by the Law on the Protection and Preservation of Cultural Property (OG 69/99., 157/03., 87/09., 88/10. and 61/11). Cultural heritage in Croatia is under the jurisdiction of Ministry of Culture. For the implementation of pilot action described in Chapter 4.1 - it is essential to obtain approval from Directorate for the Protection of Cultural Heritage, Conservation Department in Krapina.

In Croatia, in accordance with *Ordinance on simple and other construction and works (Official Gazette No. 112/17, 34/18, 36/19, 98/19)*[16]- no building permit is necessary for the implementation of pilot action described in Chapter 4.1- as long as the produced electrical energy is not intended for the grid but for the building own purposes. Renewable energy sector is regulated with a range of laws, regulations and ordinances where *Law on renewable energy sources and high-efficient cogeneration (Official Gazette No. 100/15, 111/18)*[17] is the main regulatory document.

Figure below describes the procedure which is necessary to carry out in order to implement this project *by-the-book*, all of which is related to solar photovoltaic (PV) system installation.

Necessary documents:

- Approval of the Ministry of Culture, Conservation Department in Krapina;
- Previous electric power permit for connection of the buyer with his own power plant;
- Electric power permit for connection of the buyer with his own power plant;
- Network usage agreement (low voltage power plant);

[16]Ordinance on simple and other construction and works (Official Gazette No. 112/17, 34/18, 36/19, 98/19) https://www.propisi.hr/print.php?id=7038

[17] Law on renewable energy sources and high-efficient cogeneration (Official Gazette No. 100/15, 111/18) https://narodne-novine.nn.hr/clanci/sluzbeni/2018_12_111_2151.html

- Certificate of usability of the completed electrical installation of the power plant;
- Powerless testing of the electrical installations of the power plant – report;
- Electricity Quality Measurement Report - according to EN 50160;
- PV trial work report.

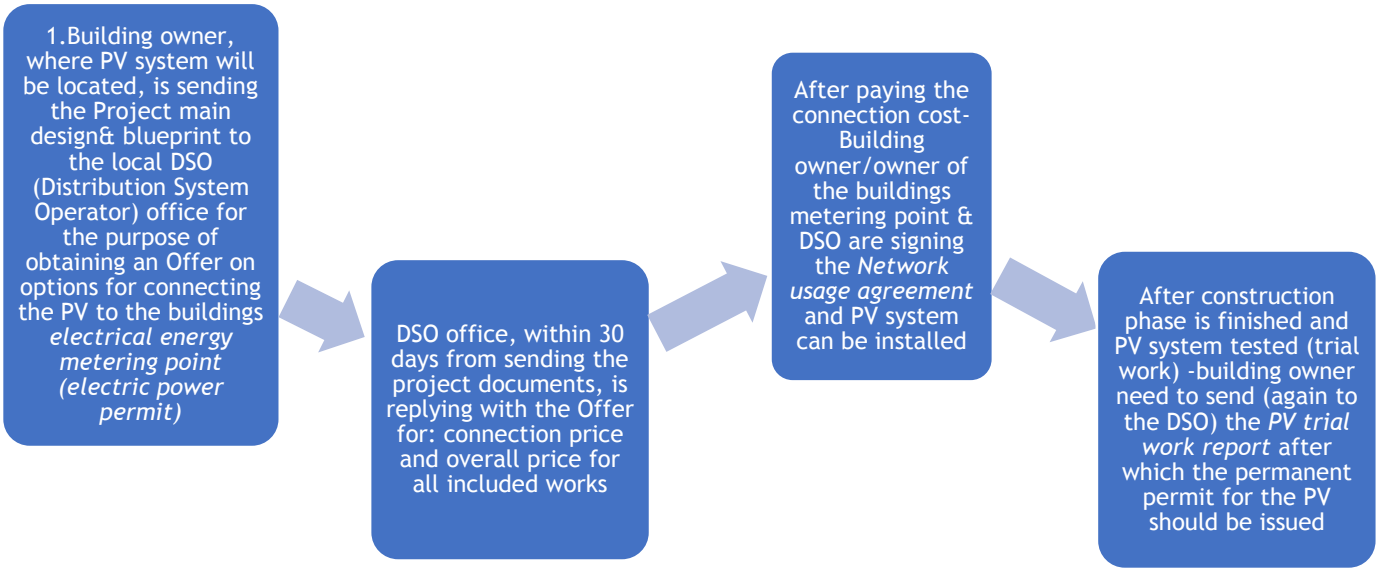

Figure 2: Photovoltaic (PV) system installation procedure Source: REGEA, 2019.

4.6. Action plan / roadmap

The general plan for procurement and works is:

- Main Project design
  - from 15.12.2019. to 1. 3. 2020.
- Execution of works
  - from 1.3.2020. to 31.7.2020.
- Connection to the grid
  - from 13.7.2020. to 7.8.2020.
- Final testing
  - from 3.8.2020. to 21.8.2020.
- Installations supervision
  - from 1.3.2020. to 28.8.2020.
- Verification of performance
  - from 21.8.2020 to 28.8.2020.
- Training

- from 27.8.2020. to 28.8.2020.

Table 3: Timetable

Activity/Phase	12/19	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20
Main project Design									
Execution of works									
Installations supervision									
Connection to the grid									
Final testing									
Verification of performance									
Training									

5. Collected feedback / summary

In course of the project Store4HUC, a feasibility study was carried out for pilot project in Bracak (HR) as an assessment of the practicality of a proposed investment plan including economic, technical, legal, and scheduling considerations. The feasibility studies outlined constraints and solutions from various aspects (technical, economic, monumental protection, status quo of HUC, ensure further implementation actions, etc.) to implement the pilot (photovoltaic system, battery storage and advanced energy management ICT system) at the historical site of the Bracak Manor (Energy Centre Bracak). The main target of the study was to enable a decision making about the pilot ("go" or "no-go" decision). In contrast to the pre-investment concept, which will be carried out in D.T.2.1.3, the feasibility study focused on first rough analysis and plausibility checks.

Within the pilot site Bracak it is planned to add a properly sized photovoltaic system (PV) and battery energy storage system (BESS). Analysis of the electrical energy consumption in Energy centre Bracak, which has 3 separate metering points for electricity (basement + first floor, ground floor and attic), showed the potential for (at least) 7kWp PV system per metering point (21 kWp photovoltaic system in total), especially if using monocrystalline panels whose production should be manageable individually with microinverter technology. Microinverters are suitable for this pilot action because of the location characteristics as well, given the shadowing which is occurring on the parking lot during the day. In accordance with the technical analysis and discussion with the Conservation Office in Krapina it is suggested that a photovoltaic power plant be installed on a steel/aluminium canopy/ies in the parking lot next to the Manor because there is enough space to install a 21 kWp power plant. Most common way to store electrical energy is to use BESS. Analysing the needs, the optimal solution is to install 3 separate battery systems, separate for each metering point with a capacity of 2,0 to 5,0 kWh (6kWh-15kWh battery system in total). In recent years, many issues regarding the disposal of toxic waste are surrounding the BESS industry so addressing the battery end-of-life issues is industry top priority. Given the role of Energy centre Bracak as a front-runner in using of new (emerging) technologies - ecologically acceptable BESS is the most logical option to implement. The already existing systems in the building will be combined with the a newly installed photovoltaic (PV) system and battery energy storage system (BESS) through advanced and smart energy management ICT system. Existing central monitoring system must be upgraded and reconfigured to create coordination service that optimally exploits different available assets. With this system, it will be possible to monitor different data such as: current electricity production, battery charge, current energy consumption and all other data from the HVAC system and the various sensors in the building in order to maximise energy efficiency. Also, Energy management system it will inherit the 3Smart (from Interreg Danube 3Smart) project concept which will enable smart management of production, consumption and energy storage and this will result in even greater energy savings.

To discuss the potential of the Bracak pilot project, on September 16, 2019 at the pilot site of the Bracak Manor (Energy Centre Bracak) was held first Deployment desk meeting. The main target of the first Deployment desk meeting was to bring together all so far envisioned relevant stakeholders, present the pilot planning to them, receive their initial feedback and agree on the next steps related to pilot deployment as well as their involvement. Deployment desk meeting was the first of four deployment desk meetings and focus was on the integration of stakeholders as well as selected players whose support will be needed for the future implementation of the pilot systems. The meeting was attended by representatives of the Krapina-Zagorje County, Ministry of Culture - Conservation Office in Krapina, Croatian electricity distribution system operator (HEP-ODS), Ministry of Construction and Physical Planning, Zagorje Development Agency (ZARA), Croatian Association of Historic Towns (HUPG) and representatives of project partners University of Zagreb Faculty of Electrical Engineering and Computing (UNIZGFER) and North-West Croatia Regional Energy Agency (REGEA). The meeting was organized as an open discussion where the planned interventions on Bracak Manor were first explained from the investment point of view (REGEA) as well as the energy management and IT point of view (UNIZGFER).

After that it was discussed about pilot site Bracak implementation with focus on potential technical, conservation and economic barriers linked to pilot action in Croatia.

Due to the chosen, innovative approach, the possibility to integrate battery system and photovoltaic system into the overall view of the historic urban centre Bračak was highlighted. Also, the installation of battery system and photovoltaic system as a renewable energy source in Bracak Pilot will directly contribute to environmental protection. With the implementation of the pilot project, it is planned to save up to 24.470 kWh of electricity per year and reduce CO2 emissions by up to 5,7 tonnes. Accordingly, the financial savings as a result of the installation of PV&BESS system and improved Energy management system, are foreseen at around 3.400 Euros per year. Preliminary calculation of Net Present Value (NPV), looking at the 25-year lifecycle period, shows that the Pilot project is financially viable to go into realization.

Based on the finding and conclusions form the Feasibility study, next step will be creation of pre-investment specification where the concept of the pilot project Bracak will be elaborated in more detail.