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Post-Workshop Report for Plug-N-Harvest Modular Façade Retrofit Workshop on Sustainable Places 2019 †

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Abstract: As part of the European Commission Horizon 2020 Plug-N-Harvest project consortium, authors hosted a 90-minute workshop to discuss issues related the modular façade retrofit development in Europe on Sustainable Places 2019 conference at Cagliari, Italy on 6th June 2019. This post-workshop report outlined research outputs presented by four speakers from Cardiff University, RWTH Aachen University, ETRA I+D and Eco Intelligent Growth. It also presented the key information discussed during the workshop. The representatives from about ten H2020 projects joined the discussions. Workshop participants provided technical suggestions on façade design, user interface development for the energy management system, circular economy business models for modular façade and consortium building. The representatives agreed that strengthening the synergy among different Horizon 2020 projects would be a benefit for all.

Keywords: modular; façade; retrofit; renewable; building; energy efficiency; Plug-N-Harvest

1. Introduction

The Sustainable Places conference is a renowned platform for the European Horizon 2020 projects to showcase their innovation outcomes and to generate synergy between different projects. This year, approximately 350 people attended the event, including 180 conference registrants from all over Europe and 100 green building professionals from local areas in Italy.

As part of the European horizon 2020 Plug-N-Harvest [1] project consortium, authors hosted a 90-minute workshop to discuss issues related the modular façade retrofit development on Sustainable Places 2019 conference during 9:00am-10:30am on 6th June 2019 at Cagliari, Italy. This session opens to all conference participants. The representatives from about 10 H2020 projects joined the discussions.

During the workshop, we discussed the challenges that EU modular façade retrofit projects are facing. Are there any other initiative/activities working toward the same direction? Which energy services do you see as the essential part of a modular façade development? What is the optimal energy management system for integrated renewable façade? How can the circular economy be applied into modular façade retrofit?

The following four speakers presented their research outcomes and the session was chaired by the first speaker.

- Dr Hu Du, Cardiff University, UK, Modular façade retrofit with integrated renewables: the definition and current status in Europe
- Dr-Ing Rita Streblow, RWTH Aachen University, Germany, The design of a modular façade toolkit
- Ms Laura Morcillo, ETRA I+D, Spain, Optimal Energy Management System at District Level
- Dr Cristina Sendra, Eco Intelligent Growth, Spain, Circular Economy applied to Build Environment

2. The Chair's Remarks

Following the recent agreements between European Parliament, the Council of Ministers and the European Commission, the European Parliament has confirmed in November 2018 new 2030 targets [2] of at least a 40% reduction in domestic greenhouse gas emission (compared with 1990 levels), at least 32% share for renewable energy and at least 32.5% improvement in energy efficiency (compared with 2007 baseline). To achieve these legally binding targets, collective efforts in carbon reduction and renewable energy generation are needed to decarbonise the existing building stock.

The Energy-efficient Building Public-Private Partnership scheme was launched in December 2008 under the European Commission's seventh framework and the Horizon 2020 programme. It aims to develop affordable breakthrough technologies and solutions at building and district scale. Until February 2019, around 600-million-euro European Union budget has been allocated for 173 project consortiums to tackle the challenges in carbon reduction and renewable energy generation [3].

Under the Energy-efficient Building scheme, a specific challenge of integrating energy harvesting at building and district level have been identified by the European Commission as one of the key priorities for research and innovation development.

3. Plug-N-Harvest Modular Façade Retrofit Development

3.1. Current Status and Scope

Over the last decade, a number of research and innovation projects have started developing modular façade retrofit solutions which integrate on-site renewable energy technologies. Although there are a growing number of academic articles and demonstration projects showcasing their achievements, the overview of current status and development trend are missing. It is difficult for policymakers, the public and fellow researchers to understand the evolution of modular façade retrofit technologies and who are the important players in the field.

This presentation firstly introduced and defined the term of Modular Façade Retrofit with Renewable energy technologies (MFRRn), then provided its classification and the review of recent evolution. The MFRRn refer to the retrofitting process that thermal insulation, solar and wind harvest technologies are integrated with the exterior finish of building using modular approach.

This presenter then reviewed projects funded under the European Commission the seventh Framework, the Horizon 2020's Energy Efficient Buildings programme, the International Energy Agency Energy in Buildings and Communities (IEA EBC) Annex 50 'Prefab Systems for Low Energy/High Comfort Building Renewal' project [4], the European Cooperation in Science and Technology (COST) Action TU1403 'Adaptive façades network' [5]. It shows that at least 14 European Commission research projects and 4 case studies mentioned in COST TU1403 and IEA Annex 50 have involved in certain of level of MFRRn development. Their research progress, timeframe, funding scale and funding flow to nations and contributions from key institutes are analysed. Finally, the current challenges regarding the MFRRn developments and implementations are discussed.

3.2. Modular Façade Toolkit

In the Plug-N-Harvest project, the modular façade toolkit consists of an aluminium frame. The dimensions of the frame are based on typical building grids that can be found throughout Europe, especially in non-residential buildings. As there are greater variations over the height of the building,

a variable element is also provided here. The modules can be equipped with the classic façade elements insulation and windows in order to reduce transmission losses. Appropriate system technology can be provided to cover the remaining energy requirements for heating and cooling. Figure 1 shows the basic structure of the façade elements. The insulation properties for the module were investigated by varying the profile design and optimised to meet the different requirements in the European countries.

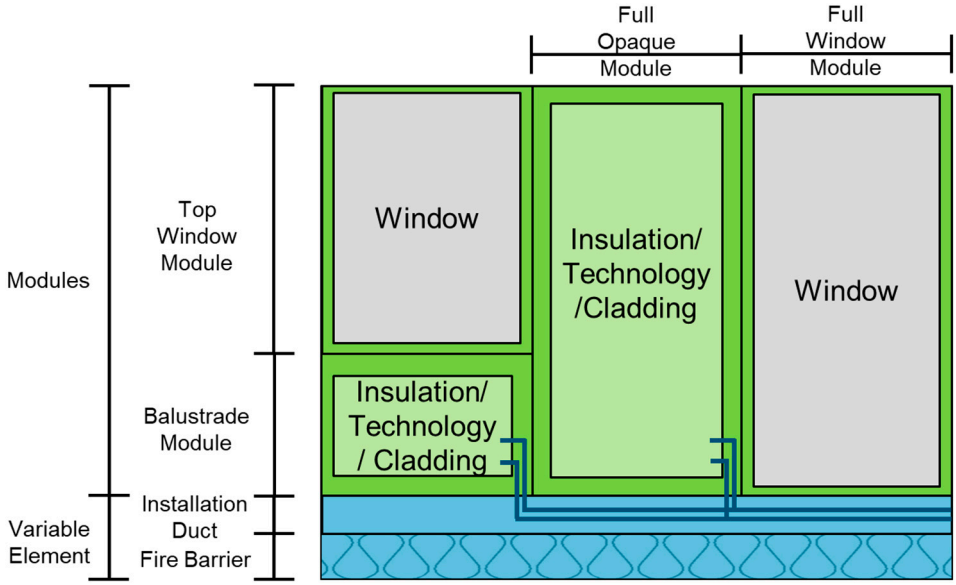

Figure 1. Modular toolbox.

The integration of the system technology takes place with photovoltaics and solar collectors as integration into the façade cladding or, as in the case of a façade ventilation unit, for example, set into the façade module. An exemplary configuration can be seen in Figure 2.

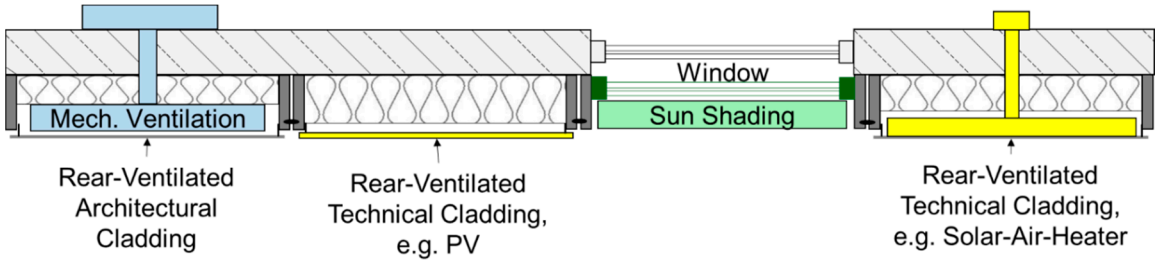

Figure 2. Configuration example.

The system integrates as much renewable energy as possible. In order to balance the differences between generation and demand, storage capacities must be provided. However, these are to be provided so far as central units in the building due to weight reasons (for the hot water storage tank) and safety requirements (for batteries).

The basic construction of the modular façade toolkit combines European and country-specific regulations. With the individual configuration, an appropriate adaptation to different buildings can be made. The toolkit is currently being adapted to the five demonstration buildings in four different countries. The interplay of all components is controlled by an intelligent energy management system.

3.3. Optimal Energy Management System at the District Level

The Optimal Energy Management System (OEMS) is a software developed by ETRA I+D at Valencia in Spain. The OEMS at the district level is responsible for the communication and energy exchange among all the Plug-N-Harvest buildings, between the buildings and the energy networks

and the communication between the buildings and external actors (such as energy service companies, ESCOs or aggregators). It allows building owners to share, store and trade energy among building, between buildings and the energy network and as well with external actors (Aggregators, ESCOs).

There are two levels of implementation of the OEMS software:

- In each building, there is optimisation software that monitors the energy-related assets (HVAC, lighting, electric heaters) and the energy-related components of the ADBE façade (PV panels and batteries) in order to calculate the overall energy consumption, production and flexibility of each building in the district.
- In each district, there is an OEMS server which receives this information from the different buildings of the district and finally, that generates the next control decisions for the considered appliances and assets in order to use the energy efficiently and provide flexibility to the district or the energy grid.

As previously commented, the OEMS takes decisions about the optimal operational status of each building for the next period based on objectives defined by the system administrator. Based on these decisions, the aggregated flexibility offered by prosumers in the district allows them to participate in Demand Response campaigns and gain economic profit through the Energy Trade Platform, which benefits users and also external actors from the energy networks.

3.4. Circular Economy

Achieving a circular economy is a critical target in the European agenda, as an alternative to the current unsustainable linear model. Considering the massive amount of materials consumed and waste produced in built environment, the impact of using circular construction products in built environment can be enormous.

The incorporation of circularity in products needs to be done since the design phase. For this purpose, 5 Circular Design Requirements (CDR) have been defined to be implemented in Plug-N-Harvest Modular Kit. The Circular Design Requirements developed are:

- CDR 1: Use safe materials. Future legislation will be stricter in terms of toxicity. If the materials used nowadays in buildings are banned in the future, its circularity will be very difficult, almost impossible. Thus products need to be made with materials that not only meet current legal requirements, but we can assure they can meet future ones.
- CDR 2: Think in System circularity. The product needs to be designed for its disassembly and future deconstruction, enhancing materials productivity and product cyclability.
- CDR 3: Preserve transparency and traceability of materials embodied in the product. Track all the information relevant along with product life with tools such as Materials Passport, to avoid waste generation.
- CDR 4: Keep track of valuable and Critical raw materials embodied in products.
- CDR 5: Rethink business model and define a new partnership with different stakeholders to implement business models that support a circular transition.

Other complementary tools, such as Circular Material Database, Circular Business models, Material passport and deconstruction Plans will be defined to ensure Circularity of Plug-N-Harvest Modular Kit.

4. Discussions

Reflecting on the four presentations, representatives from ongoing H2020 projects including RenoZEB [6], P2Endure [7], ProGETonE [8] commented that there is an excellent synergy between Plug-N-Harvest and their projects. From both projects' delivery and European Commission's perspective, strengthening the synergy on products development and establishing a common platform for dissemination activities would be a benefit for all.

In terms of façade design for buildings with overhang balcony, a unique solution has been tested in ProGETonE project. Adding one piece of new façade to the external edge of the balcony not only

brings improved thermal comfort but also increases usable spaces for the building. This solution is welcomed by building owners and occupants due to the added value to the property. However, regulatory restrictions might prevent this to happen. Depending on the type of usage, this solution might have great potential for residential buildings. Office buildings (typically use the balcony as fire evacuation route) might not be willing to take this solution.

In terms of user interface development for the energy management system, it is crucial to develop bespoke designed interfaces for each type of users. Occupants, building managers, building owners and Distribution Network Operators require different levels of information and functions.

A common challenge for all projects is that the local legislation and Distribution Network Operators (DNOs) may not allow implementing complex energy trading system. Pushing for new legislation and engaging with DNOs are the only option to move to higher TRL. In the framework of the Plug-N-Harvest project, as there is no DNO in the consortium, the Energy Trade Platform will simulate the behaviour and commands coming from the DNOs.

Presentation on circular economy proposed a great theoretical model. Plug-N-Harvest modular Kit can be an example of a circular design framework to develop circular Business models, which can preserve materials used in buildings. However, audiences look forward to seeing how the model to be applied to real demonstration projects. Audiences also mentioned that costs would be a decisive factor for the market penetration of modular façades. In order to be competitive here, new business concepts are necessary.

5. Conclusions

The 'Plug-N-Harvest modular façade retrofit workshop' on Sustainable Places 2019 conference facilitated fruitful discussions between different ongoing H2020 projects on project delivery progress, technical challenges and future directions.

The workshop consisted of four presentations from H2020 Plug-N-Harvest project team members. The first presentation introduced and defined the term of Modular Façade Retrofit with Renewable energy technologies (MFRRn), then provided its classification and the review of recent evolution including the outcomes from 14 European Commission H2020/FP7 research projects and case studies mentioned in COST Action TU1403 Adaptive Façades Network and IEA ECBCS Annex 50. The second presentation illustrated the concept design of modular façade retrofit toolkit within the H2020 Plug-N-Harvest project. The third presentation showed the recent development of the Optimal Energy Management System at the district level. It allows building owners to share, store, trade energy and trigger demand response events within the district and with the grid. The final presentation introduced the circle economy aspect of the Plug-N-Harvest design which is based on 5 Circular Design Requirements including the use safe materials, design for cycling, transparency and traceability, control on critical raw materials and circular business models.

The participants agreed that strengthening the synergy among different projects would be a benefit for all. An initiative to host a joint workshop among several H2020 projects under the theme of 'modular façade retrofit' could be the next step to move forward.

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Conflicts of Interest: The authors declare no conflict of interest.

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