Pre-fab & Integrated renovation toolkits: an opportunity for social housing?

Screening of business models for renovation toolkits

HEART

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1. EXECUTIVE SUMMARY

As a contribution to Work Package 8 'Exploitation of the project results' and Task 8.2 of the HEART project 'Screening and definition of business models', this report looks at the current state of the market for renovation toolkits in Europe.

The report focuses especially on the supply and the demand of social, public and cooperative housing providers, a sector that is increasingly looking at new solutions to be able to meet the ever-increasing renovation challenges in terms of quantity and quality.

Pre-fabricated and integrated renovation concepts promise to offer better outcomes in terms of delivery speed, cost & affordability, comfort and end-user demands. Through a market review, Housing Europe has been screening different models of renovation toolkits in Europe, such as the one being developed in the EU-funded HEART project.
We looked at the current supply is and tried to assess how this (nascent) market for renovation toolkits will evolve in the coming years. Based on desk research and many interviews we assessed what solutions are out there for social housing in the current market for renovation toolkits; what the size of the market is and what the barriers need to be solved.

The report's outcomes highlight a number of important issues to be taken into account for a further market uptake of renovation toolkits and the role of the social housing sector. First of all a share of the social building stock, depending on the construction period and the programmed renovations cycle, should be suited for the use of renovation toolkits because of uniform and wide-spread typologies. It is estimated that on average 30-50% of the (social) housing stock would be fit for such mass-customized renovations, which is already a huge potential market at national and European scale.

There is also strong awareness of the combined challenges of decarbonization, energy performances and housing affordability among social housing actors and construction partners. Having housing stock data, analysis and information is crucial to organise and finance building renovations process in a more efficient manner at national, sectoral and organizational level.

Current renovation toolkits are often perceived as too expensive. Cost-savings have not been fully achieved because of a low market-uptake and limited economies of scale. Additional investments could solve this chicken-or-egg dilemma and reap the potential. Contrary to some perceptions, it is important and possible to balance a further industrialization process with the involvement of local companies and SMEs.

For all this to happen it is important for all actors in the supply chain and on the demand side to think about the big picture and the longer-term effects. This also means that renovation toolkits should be adapted to the step-by-step renovation approach that is preferred by a share of housing providers instead of deep big-bang renovations.

Another stimulus would be to strengthen renovation targets and national renovation roadmaps that provide clear investment horizons while allowing multi-year step-by-step approaches.

For the Heart renovation toolkit, this means the modular approach that combines and optimized different elements should be an attractive offer. Especially the strong data monitoring and BEMS aspects were seen as very interesting in HEART. The algorithm allowing to have a monitoring and feedback on performances is a real plus. The availability to gather, exploit and use data will be key to move towards more performance-guarantee based offers from the market. In that sense, the political will and regulatory flexibility are required to make this possible in the future.

These conditions need to be met to allow the further uptake and development of renovation toolkits. Not only to achieve lower costs and increase acceptance among residents. The use of such toolkits (in different forms and shapes) is simply essential to take on the enormous renovation wave of the building stock in the coming decennia and overcome the limited human and material resource.

2. CONTEXT

2.1. BACKGROUND

This report has been drafted in the scope of the EU-funded HEART[1] project which develops a renovation toolkit which incorporates different components and technologies, which cooperate to transform an existing building into a smart building.

The main aim of Task 8.2 of the HEART project is the 'Screening and definition of business models' to identify a set of economically feasible and sustainable business models for the adoption of HEART toolkit in the EU Market[2]. This will contribute to the selection of the best business models for the exploitation of the result of the HEART project. Task 8.2 will be carried out according to the following key points:

1. SWOT analysis and risks assessment. The activity will consist in the deep evaluation of the aforementioned business models. A SWOT analysis will be carried out in order to highlight the main threats (and weaknesses) to the spread of the proposed technology. Its development could be in fact influenced by both endogenous (changes in operational or capital costs, modifications in the regulatory framework, etc.) and exogenous factors such as the future trend in energy tariffs.

2. Economic feasibility and sensitivity analysis. The activity will consist in the drafting of an economic feasibility study, comparing required investments with potential revenues and cost streams, thus letting to select a limited number of potentially feasible business models to be then further exploited after the end of the project. The feasibility of the models will be tested also taking into account the presence of incentive mechanisms (either bill-on repayment or tax-finance) in the different countries. Most risky and significant variables will be subject to a sensitivity analysis showing their impact on the economics of the investments.

The aims is to offer insights to the SWOT analysis and the economic feasibility study.

2.1. RESEARCH QUESTIONS

POLIMI drafted a Business Model Canvas options (see Annex 1) to assess which elements of the Heart platform are the most feasible options to bring to the market (in the segments: social housing, mass market and premium market).

Based on this Business Model Canvas, the contribution of Housing Europe consisted in an analysis of the current market for existing renovation toolkits/pre-fab solutions, as seen through the eyes of social housing providers. This market analysis will be used to enhance the business model for

[1] **H**olistic **E**nergy and **A**rchitectural **R**etrofit **T**oolkit
[2] Involved partners: POLIMI, HE, ALL OTHER PARTNERS. Deadline Final Report D8.2: M36 – 30/09/2020.

facility management company and social housing providers[3]. The research provides more insights into the questions such as:

- How is the supply and demand for renovation toolkits for social housing likely to evolve in the next 3-5 years segment?
- What are the best solutions provided in the current market for renovation toolkits/prefab in SH?
- What is the size of this market?

In order to conduct the market analysis, the first step was precisely defining the term “toolkit”. As renovation toolkits can encompass a variety of tools, it was important to fix one definition to set boundaries to this research.

Regarding the HEART toolkit, we note it combines different components and technologies: HVAC, systems, BEMS, energy storage, heat pumps, prefabricated façades, BIPV and more. These elements are connected and controlled to function optimally with each other, transforming existing buildings into smart buildings.

This is achieved via a cloud-based algorithm, optimising the performance during the use stage and a Decision Support System during the preparation stage. Furthermore, the elements of the HEART toolkit are prefabricated, making it possible to do larger scale renovations against reduced costs.

Our market analysis is focusing on renovation toolkits in a broader sense. That is to say, the existing offer for prefabricated renovation packages at an industrial scale (e.g. Energiesprong-type approaches), instead of case by case renovations. Those toolkits are packages of prefabricated and integrated components aiming at deeper renovations of homes that are quick, high quality and affordable. This requires more and more digital solutions, such as BIM, 3D scanning, point clouds, smart homes/grids, and data at portfolio levels.

For this research we used a broad definition of ‘renovation toolkits’ in this nascent market:

“Packages of pre-fabricated, industrialized and integrated components (e.g. pre-fab insulation/façades, HVAC, (renewable) energy systems, user interfaces) and digital solutions offered by one (group of) supplier(s) to ensure quicker, higher quality and more cost-effective home renovations."

2.2. METHOD

The core of this analysis focuses on a series of interviews conducted with both the supply and the demand side of the (potential) market for renovation toolkits. The idea was to have the direct input of actual (niche) market actors to understand the structure and development potential. The 12 interviews gave a first picture of the market which was complemented by desk research that included an analysis of other initiatives to develop renovation toolkits.

[3] Originally planned to be presented at a HEART workshop meeting in April in Milan, but postponed due to COVID-19.

3. RESULT OF RESEARCH

3.1. DATA ON SOCIAL HOUSING STOCK IN EUROPE

The possibilities to roll-out renovation toolkits depend, among other things, of the market segmentation (e.g. share of private owners with more heterogenous demands vs larger housing organization and sectoral organizations that can influence the supply side) and the existing buildings typology in a country or region. The following data gives an overview of the housing stock based on survey among Housing Europe members which manage social/public/cooperative housing[4].

Most strikingly, and relevant for renovation toolkits, is that around three quarters of the current social housing stock is older than 30 years. On average in the EU-16, 40% is older than 50 years. This means many buildings should undergo (structural) renovation works in the coming years just to keep up the current quality of the housing stock. On top of that national and EU plans target the upgrading of the current building stock in terms of energy efficiency and the use of renewable energies.

Among the social building stock, depending on the construction period and the programmed renovations cycle, a share will be more adapted for the use of renovation toolkits because of a more uniform and wide-spread typology. E.g. standard row houses or low apartments blocks that were constructed already in an industrial manner 30-50 years ago.

Figure 1 - Construction period - social housing stock (in thousands)

	>50 years	30-50 years	20-30 years	10-20 years	<10 years	Total
EU-16	8.573	7.939	2.052	1.536	1.499	21.599
Austria	181	140	108	101	86	615
Belgium	103	104	27	36	29	298
Czech Rep.	130	290	200	25	5	650
Denmark	230	209	70	39	24	573
Estonia	10	31	5	3	3	52
Finland	96	114	38	36	32	317
France	1.348	3.147	597	459	711	6.263
Germany	3.568	1.737	255	255	112	5.926
Ireland	2	1	7	15	11	35
Italy	360	206	40	32	14	653
Luxembourg	0	-	-	0	0	0
Netherlands	834	850	240	188	160	2.272

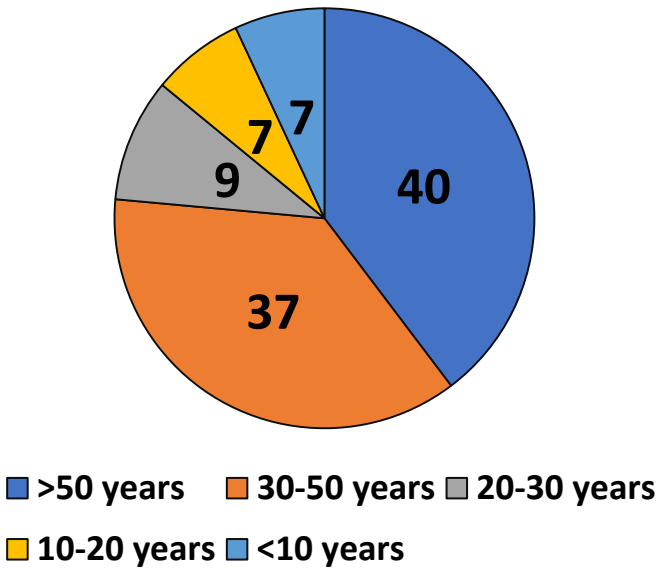
[4] Based on the Housing Europe report "Investment of the Social and Affordable Housing Sector in Europe" (2020, not published) with responses from Housing Europe members from 16 countries; Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Slovenia, Spain, Sweden, United Kingdom (Ex-Northern Ireland)

Slovenia	2	0	1	1	0	4
Spain	100	70	33	29	18	250
Sweden	260	310	146	33	66	815
UK	1.348	730	285	285	228	2.876

Figure 3 - Construction period in percentage of stock

	>50 years	30-50 years	20-30 years	10-20 years	<10 years
EU-16	**40**	37	9	7	7
Austria	**29**	23	18	16	14
Belgium	34	**35**	9	12	10
Czech Rep.	20	**45**	31	4	1
Denmark	**40**	37	12	7	4
Estonia	20	**60**	10	5	5
Finland	30	**36**	12	11	10
France	22	**50**	10	7	11
Germany	**60**	29	4	4	2
Ireland	4	3	20	42	30
Italy	**55**	32	6	5	2
Luxembourg	6	-	-	6	88
Netherlands	**37**	**37**	11	8	7
Slovenia	**63**	2	15	15	5
Spain	**40**	28	13	12	7
Sweden	32	**38**	18	4	8
UK	**47**	25	10	10	8

Figure 2 - Average age of social/public/cooperative housing stock in Europe, in percentage of stock



3.2. OUTCOMES OF THE MARKET SURVEY

3.2.1. Demand side

During the months of May 2020, Housing Europe conducted a series of interviews with different stakeholders from both the demand side to understand their position towards renovation toolkits: what are the needs among social/public/cooperative housing providers? What is the current offer in this small but growing field? What are the current barriers? Etc.

In total, seven interviews were conducted to hear the demand side. A set of questions was shared with the interviewees:

- What would be the reason why customers turn to HEART-like renovation toolkits instead of the current offer?
- What are the specific needs in social housing regarding renovation toolkits (for deep renovations)?
- What do you see as the main benefits of renovation toolkits for social housing? How interesting is the option to work with such toolkits? (1-10)
- What proportion of your housing stock do you estimate is fit for renovation toolkits?
- Which market players should develop renovation toolkit for social housing?
- How do you see the trend of industrialized and smart reno toolkits evolve in the coming years?

These questions provided a starting point, but we allowed to deviate from this frame in order to leave sufficient freedom to the interviewee to address matters that seemed relevant to them.

The persons interviewed for the demand side were:

- Gordon Watts, Sustainability manager, and Jon Parkin, property services and retrofits at SYHA, UK;
- Paul Sachot, Rehabilitation and Maintenance manager at Est Métropole Habitat, France;
- Marco Corradi, director of ACER (Azienda Casa Emilia Romagna) di Reggio Emilia, and Margherita Iacconi, Social Management Office at ACER, Italy;
- Wim Hazeu, CEO at Wonen Limburg. Also chair of the Energy committee of Housing Europe
- Nicolas Cailleau, Energy manager and Carine Puyol European affairs manager at Union sociale pour l'habitat, France;
- Fabian Viehrig, Head of Building and Technology at Department Energy, Building, Technology, at GDW Bundesverband deutscher Wohnungs- und Immobilienunternehmen, Germany;

- Johannes Fechner, consultant at “17 und 4”, Austria.

Awareness of decarbonization, energy performances and housing affordability

All actors interrogated have adopted a more energy conscious approach when renovating buildings.

As representatives of housing providers, Gordon Watts (SYHA), Marco Corradi (ACER) and Nicolas Cailleau (USH) acknowledged the importance to reduce carbon consumption in the building sector and said that this point is now present in their companies’ strategies. For Johannes Fechner (17&4 consultants), we must redefine what is needed as a standard and what is needed as a roadmap to change in the next 20 years.

Some organisations have taken concrete actions: for social housing provider Wonen Limburg and the French federation USH, energy performance is a key criterion when assessing building stocks; SYHA is looking at modern methods of construction (MMC), building methods that consumes less carbon; in France, new tools are being developed such as a new programme for energy efficiency certificate of buildings called Gorenove, that is a decision aid tool (piloted by CSTB).

Better energy performances are also seen as one way of managing and lowering rent: Marco Corradi (ACER) explained that in Italy, the people spend over 30% of their income for their rent, some over 50%. In social housing, more than 40% of tenants are in this case. The main share of the rent costs is related to the energy and maintenance costs of the building. The result is that some of those people cannot pay their rent.

All of the organisations interrogated would be interested in rehabilitation toolkits for this first reason. For them, to take up the large-scale decarbonization challenge of the housing stock, it is crucial to find new – more affordable and quicker - ways to renovate. Toolkits are part of the answer.

Toolkits and data

Having housing stock data is crucial to make building renovations process more efficient

For Gordon Watts (SYHA), today, one of their biggest challenge is to assess the retrofit measures and associated costs at a portfolio perspective. This is difficult due to incomplete data. They lack finer data at component or system level. Such data would help them understand the drivers of energy consumption for each building. They are currently working on getting more detailed data.

Nicolas Cailleau (USH) also pointed that social housing providers need to have a simple cartography of their stock’s performance to be able to position themselves. They need to identify their stock’s characteristic and energy performance to understand which type of renovation measures could potentially benefit from the supply of renovation toolkits in certain areas or segments.

In that sense, the data and the cloud part of the HEART toolkit should be able to help to scan and collect data at portfolio level to better understand the buildings’ readiness for renovation toolkits and bringing more suitable answers.

Questioning the traditional building sector's functioning

Balancing industrialization and local companies

For Gordon Watts (SYHA), when looking at such initiatives, the scale is key. He is already noticing that small, and medium sized companies are holding talks to organize themselves to have more market power and achieve the required economies of scale to put innovative renovation solutions in the market. While automatization and off-side building are part of the solution, local employment, certainly remains part of the considerations.

For Nicolas Cailleau (USH), the development of an economic activity by local actors, in parallel with industrial solutions, will only come in a second phase, when they will recognize the market potential. Only then will local industries organize themselves to answer this demand. He does not expect that these small local companies/contractors will necessarily have less work due to the industrialization of the renovation offer. It depends how small artisans will be able to integrate in the industrialized supply chain. They can be sub-contractor or be in charge of installing prefabricated pieces built by a bigger factory. Industrialisation and a strong local economy are not incompatible and, indeed, necessary. We can see by looking at Energiesprong for instance that the industrial tissue is forming at local/regional level. Moreover, at long term, the circular economy logic will strengthen the local elements of bio-sourcing, short supply chains, and using and recycling abundant and circular local resources.

What role do public authorities have to play to help implement HEART-like toolkits?

For Paul Sachot, public authorities have an important role to play in the development of a market for renovation toolkits because they have the power to structure the market. There is a need for the public sector to stimulate a boost in the supply and the smart demand. For him, public authorities should have a role in by helping the demand side to regroup, organize mass-tenders and negotiate prices and volumes in order to create the require large scale production facilities.

For Nicolas Cailleau (USH), there is a need for a collective approach with a market analysis and confronting supply and demand. It is not possible to get to renovations with more controlled costs if we do not confront the supply side.

Marco Corradi (ACER), gives the example of the Italian government who wants to restart the economy by including a strong programme of buildings renovations with fiscal incentives, for deep and anti-seismic renovations. The government also wants to give credits for ESCO services.

It has also been pointed, by Fabian Viehrig (GDW) that sometimes, public procurement law for the public sector (EU and national) makes it difficult to make free decisions. The fact that one of the most successful renovation toolkits initiatives (Energiesprong) started in the Netherlands was also made possible because the (private not-for-profit) social housing providers were able to challenge the market as companies, not as public sector bodies that are tied to EU public procurement rules.

A more holistic approach and new roles for historical actors

It came up several times in the interviews (ACER, USH, GDW) that the building sector is very fragmented, and stock's renovations are still done in an, almost artisanal, step-by-step manner.

This is not efficient enough and inadequate in the light of the scale of the renovation wave of the coming years.

The new environmental and energy requirements, and the toolkit's approach require a more integrated approach. First, the new environmental and energy requirements force actors to collaborate to work together: Nicolas Cailleau (USH) gave the example of the implementation of air insulation level that has forced electricians and plumbers to work differently. These new requirements request to broaden the perimeter of action and the skills of historical actors.

This new approach also requires a change in the way contractors are chosen: Wonen Limburg used to do traditional tenders based on best price to choose a renovation company. Now for their "1.000 renovations per year" project they require specific result in terms of energy performance, with no strict requirement on the process, technology, or delivered. The price is set in advance based on their knowledge and discussions of the market. It is not output driven, but outcome based.

Advantages that the social housing sector brings regarding rehabilitation toolkits

For Paul Sachot (EMH), the social, public, and cooperative housing sector is a key actor for renovation toolkits because they are able to commit to build a certain volume of houses. It can also create a pull factor for additional efforts in the privately owned housing sector, because if social housing apartments are rehabilitated, they can become more attractive than apartments from private owners or small landlords. They also prepare the terrain for other actors that see the outcomes such as co-proprieties, schools, public buildings, etc.

The building sector is already adapting to the paradigm shift brought by the necessity of an ecological transition. The renovation toolkits' logic is in line with this dynamic and can contribute to speed it up.

Toolkits are seen as still expensive and too complex

Energetic renovations are too expensive on the current market

For most of the people we interviewed (EMH, SYHA, GDW), the issue is that energetic rehabilitations need to cost less. Hence a need for more industrialization. For Fabian Viehrig (GDW), the most important thing is to reduce the complexity of energetic renovations and to eliminate uncertainties regarding costs and time. If it is then possible to generate a really attractive price, a breakthrough could be achieved.

Prefabricated solutions are still too expensive too

For Paul Sachot (SYHA) and Wim Hazeu (Wonen Limburg), the prices offered by renovation toolkits are still high. Wim Hazeu gave the example of Energiesprong: for the façade it costs €100.000 to renovate a dwelling worth € 140-150.000. For Fabian Viehrig (GDW), the gap between the energy savings and the necessary allocation of all construction costs is considerable.

It has also been brought up (Wim Hazeu, Wonen Limburg) that the upscaling does not always lower the price, because the development phase and the scaling up also generate costs.

A chicken and egg problem

This costs issue can be summed up as a chicken and egg problem: the social housing sector needs the prices of renovation toolkits to be cheaper to afford large orders. The way to decrease the prices is to industrialise and scale up the production. But to scale up their productions, the companies need a lot of orders from housing associations.

Favoring adaptability over standardization

The biggest challenge for the toolkit products is probably flexibility and adaptability to the local situation. For several organisation (EMH, GDW), such toolkits cannot be applied on their complete social housing stock. For some buildings only facade kits will be suitable and for others complete kits will be possible. It would be interesting to have a diversity of supply, different kits, like different car models/options.

It has also been pointed out that one of Energiesprong's characteristic is mass customization and hyper standardization. It brings the risk of having too much similar looks and impoverishing the architectural legacy. Nicolas Cailleau (USH) has noticed a resistance towards the Energiesprong project due to that.

However, in comparable projects for serial building, this type of adaptations has led to strong cost increases, which sometimes overcompensated the advantages (Fabian Viehrig (GDW)).

The cost remains the main drawback for renovation toolkits, as the potential savings promised on energy consumption do not compensate the costs to invest for the rehabilitation itself, nor the complexity of those new tools.

In summary, there seems to be agreement about the following pros and cons regarding the industrialisation of processes and the development of integrated renovation toolkits:

Pros:

- The industrialized process of renovation toolkits promises lower energy rehabilitations costs and increase the delivered quality and performances.
- Industrialisation reduces the complexity of energetic renovations and eliminates uncertainties regarding investments costs, time and delivered energy performances.
- In the case of HEART-like toolkits, industrialisation is synonym with new renovation methods whereby elements can be optimally integrated to increase the energy efficiency of dwellings
- Industrialisation allows for a more holistic and coordinated approach along the supply chain
- Small companies can collaborate with bigger factories to offer renovation toolkits (e.g.: being sub-contractors)

Cons:

- The integrated supply of renovation toolkits requires large up-front capital and higher investments risks.

- Dilemma between finding economies of scale and preserving local employment
- Industrialisation of rehabilitation processes usually lacks in adaptability, making it difficult to implement on all types of buildings
- Industrialisation also means standardisation which could impoverish the architectural legacy
- The development phase and scaling up process generate start-up costs, so industrializing does not always lower prices as expected

Thinking on the long term

However, for Johannes Fechner (17&4), it is important to look at the big picture. Consider the life expectancy of the existing components changes the cost perspective. These elements need to be changed in any case and investment costs are already budgeted. Hence, the question is more about acceleration and the deepening of interventions.

Paul Sachot (EMH) agrees that the rentability of the renovation has to be studied on the long term: if the renovation is quicker than the traditional renovations, it will create more rent revenues for the landlords. Looking on the long term also means choosing wisely which technology to use.

Wim Hazeu (Wonen Limburg) notices that there are big developments ahead of us in the technologies that will become available for the energy transition. We have to make a step today, but it will likely not be the best and cheapest technology available. For example, the heat pump and (renewable) energy and HVAC systems will become much better and become the standard, meaning that we will be able to optimize on insulation costs. Also, technologies are going to develop faster than the rate at which we can implement projects.

This does not mean a wait-and-see approach is being advocated. Instead, a step-by-step approach whereby renovation toolkits can be delivered incrementally as modules during each of the natural intervention moments (e.g. every five years), could drive more renovations by making them more feasible from an economic and technical perspective, while being less intrusive.

A long-term vision is key to accept new ways of rehabilitating buildings, which became necessary to complete the energetic transition. However, social housing providers are used to look at the mid-term and make portfolio, financing, and renovation plans at a shorter term (max. 5 years ahead). Changing that perspective might be challenging.

About HEART

Finally, specific points and requirements were mentioned by some of the organisations regarding the HEART toolkit.

One respondent highlighted that a renovation toolkit solution based on a data platform should integrate the renovation needs at a national level (e.g. BRE in UK). Such an internal database should include live updated products, including cost ranges. This would enable social housing

provider to integrate the platform with their own portfolio management software and model live data, as a dynamic tool. With the right training and online support to use such an intuitive tool, it should be able to apply and simulate rules (e.g. based on policies, decarbonization goals, min energy performances in year X, cost limits, etc.) to create specific scenarios and the ability to (mass-)customise the toolkit for each property. (Gordon Watts, SYHA)

The need for HEART is very important because currently the renovations are not smart and are ineffective. With the pilot in Bagnolo, ACER have seen a big jump in technology and the reduction of costs was 80%. Moreover, the energy savings were 45-50%. Because of the technology and management possibility. The integration of the elements and the high technology level are the most attractive features of HEART for them. (Marco Corradi, ACER)

The monitoring aspects is very interesting in HEART. The algorithm allowing to have a monitoring and feedback on performances is a real plus. These companies will be the leaders in the industry tomorrow. The availability to gather, exploit and use data will be key to move towards more performance-guarantee based offers from the market. (Nicolas Cailleau, USH)

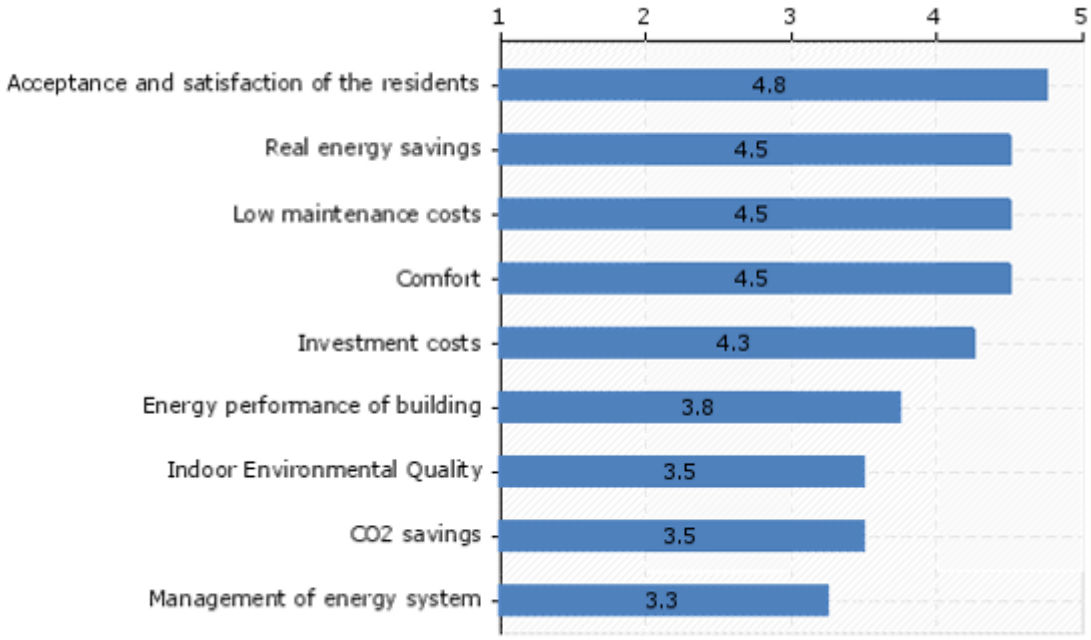
Housing Europe's survey, March 2019

In addition to those interviews, Housing Europe already conducted a first survey among social housing providers to better understand their needs for renovation toolkits and the relevance of HEART solutions. The survey assessed the demand for integrated toolkit solutions among social/public/cooperative housing providers.

The questionnaire was designed together with EURAC and distributed among the membership of Housing Europe between January and March 2019. The aim was to assess the demand for integrated retrofit solutions like the HEART toolkit and to learn how to adapt it to the renovation needs of housing organisations.

The results are based on responses from four professionals working at different housing providers located in France, Spain, Sweden, and the UK.

When asked which elements are the most important for their housing organization when evaluating solutions for renovation works, the acceptance and satisfaction of residents ranked first, followed by real achieved energy savings and low maintenance costs. The level of comfort of residents was also found important.



All the respondents answered that a commercial solution that puts together all elements of a renovation process in a single integrated energy renovation toolkit was attractive or very attractive.

It was found positive or very positive if such an integrated energy renovation toolkit would provide a list of pre-selected components and manufacturers.

The fact that the management and operation of different systems and sub-components is optimally fine-tuned by an intelligent system (the HEART computing platform) that also provides for real-time monitoring and performance testing, was found important or very important.

100% of respondents answered it is attractive that renovation works are done by a single renovation consortium that is certified (and trained) to install the HEART toolkit and all its sub-components.

Having a computer system assisting in the decision-making about the optimal combination (energy and cost) of retrofit elements is relevant or very relevant for all respondents.

Referring to the HEART toolkit, 3 out of 4 said it was likely that they would consider such a single integrated energy renovation toolkit as an option in future renovation projects. One respondent mentioned this was depending on the ease of use, on the realized performance in practice, and on the investment cost of the toolkit.

The Total Cost of Ownership (TCO), including maintenance and operational costs, is very important for 100% of respondents in their selection procedure of renovation works and techniques. The same holds for energy management and maintenance costs in the use phase after renovation is completed.

The selection of the renovation systems (e.g. Building Energy Management Systems, Heating, Ventilation, Air Conditioning, Photovoltaics, Envelope Technologies/Insulation materials, ICT

technologies) is done by the housing organization itself in 75% of the cases. One respondent informed this was decided by an architect/designer/civil engineer.

A less uniform picture appears when asked about the usual select procedure for renovation solutions. One uses direct commissioning to one contractor, one uses its own in-house renovation department, and one organizes a public tendering based on economically most advantageous offer (e.g. taking into account total cost of ownership, energy performance, energy savings, CO2 savings, etc.)

These results will feed into the work of T2.1 ´Buildings retrofit market´ and T2.6 ´Users' needs and communication techniques´ of HEART.

Although the limited number of respondents in this survey it helped to shed some light about the expectations from the social housing sector regarding the solutions that HEART provides. It also raised additional questions that could be included in follow-up research:

- The increasing use of tailormade 'mass-customized' concepts and their market feasibility
- The ideal geographic scope (not too large for logistics) and housing stock (as large as possible) for a manufacturer or facility manager
- Opportunities to include circular concepts that improve the quality of renovations (e.g. in terms of affordability, comfort, durability, and flexibility)
- Member States' and EU policies to support the further development and market uptake of cost-effective renovation toolkits

3.2.2. Supply side

During the month of June 2020, we conducted a series of interviews with organisations working in the housing sector specialised in energy issues or with people working on similar projects, to understand their position towards renovation toolkits: what is the current offer in this field? What are the latest innovations in the market? How do they see the market for renovation toolkits and smart systems evolving for larger building managers such as social housing providers?

In total, five interviews were conducted to hear the demand side. A set of questions was shared with the interviewees:

- What is the size of the current market for renovation toolkits?
- How do you see it evolve in the next years?
- Why are renovation toolkits attractive? How could we make HEART more attractive?
- What is the best solution currently on the market?

These questions provided a starting point, but we allowed to deviate from this frame in order to leave enough freedom to the interviewee to address matters that seemed relevant to them.

The persons that were interviewed representing the supply were:

- Ulla-Britt Krämer, Project leader sustainable energy, INUD-ZERO for the province of Overijssel, Netherlands
- Ron van Erck, Energiesprong's Head of international market development, Netherlands
- Hugo Vigneron, Operene, France
- Christopher Sykes, Director general at Construction Products Europe
- Janne Rieke Boll, Research and Communication Associate at Buildings Performance Institute Europe (BPIE)

A promising market for renovation toolkit

Estimation of the potential market

All of the interviewees agreed to say that there is a market for renovation toolkits, and that it is growing. The estimations of the size of this potential market vary between all of them: for Ulla-Britt Krämer (INDU-ZERO), around 30-40% of the total social housing stock would be fit for mass-customized renovations, for Janne Rieke Boll (BPIE), the minimum scale for renovation toolkit facilities is estimated by BPIE at 70-80.000 renovations/year, Ron van Erck (Energiesprong) is close to that estimation, saying that the minimum size of market required to have economies of scale is around 50.000 renovations/year. He also adds that "if the product is right, there will be a market for it".

To be more precise, and better understand the potential market, Ron van Erck (Energiesprong) divides the dwelling stock into three categories. In those three categories, the rehabilitation solutions rely on off-site manufacturing, high level of integration of elements (insulation, generation, HVAC, rooves, façades), with predictable and constant energy levels.

1. Newbuilds. Up to 90% of this market could be interested by retrofit packages. It depends on the level of customization people require for their dwelling.
2. Typical Energiesprong retrofit market: mostly post-war stock, 50-60's archetypes with long structural lifetime. Those are perfect for a whole house makeover, especially the envelope and energy systems. The size of this market depends on the country. In the Netherlands 3,6 million homes fit that description (more than 50% of stock), in the UK and France 40-50% of the housing stock is concerned.
3. Houses built in the 1930's, with more complex facades, with an architectural value. It is more complicated for external renovations, so partially prefabricated solutions are more suitable. Usually those buildings need a new roof, triple glazing, energy module and additional bespoke intervention. In general, they represent around 30-40% of the market.

The covid-19 crisis could extend the renovation market

One element that is important to consider is the covid-19 crisis. As pointed by Christopher Sykes (Construction Products Europe), many of the production lines have been switched off recently, causing big loses in the sector and lots of layings-off. For some of those companies it is very costly to restart. Thus, the situation in the building sector will be very different next year. That is why

renovation is seen as a saviour for the sector right now, because if there are no new constructions, renovation is needed to keep the construction sector afloat.

Potentially, this could significantly increase the demand for renovation toolkits and the renovation sector could "take advantage" of the crisis to grow bigger, since there are few new constructions. The further development of renovation toolkits can be a part of the recovery by making renovations easier and quicker and an important element of the renovation wave.

Janne Rieke Boll (BPIE) also explained that this pandemic could help start a market for renovation. Indeed, BPIE have recommended launching a renovation fund, as part of the covid recovery plans. The buildings that could be concerned by this fund are mostly buildings from the 1950-60's, so this is a lot of buildings in Europe. They have calculated that 8% of the buildings in London would be suitable, and in Germany, 500 000 buildings are fitting for the Energiesprong-like renovation toolkit approach. They have also calculated that a renovation fund supporting 30% of this stock could start a market. She added that social housing could be a good segment to start with.

It is then safe to say that, for the actors interviewed, renovation toolkits will find a market, and that the actual circumstances (the covid crisis, the renovation wave) are beneficial for the sector.

A promising market of providers

Numerous and diverse providers

If several projects are already working on renovation toolkits across Europe, the number of providers of said toolkits' elements in this niche market is also growing, and diversifying. The type of actor ranges from bigger companies to smaller innovative start-ups. Janne Rieke Boll (BPIE) noticed that, on the Energiesprong website, they have a list of all their providers, twelve of them dedicated to facades. Ron van Erck (Energiesprong) is also seeing different players: a start-up in Germany has raised 5 million euros for such a product, two start-ups in the UK are working on similar projects. Big companies are also entering the market: component manufacturers are getting in the market too and taking over typical contractor role.

The importance of SMEs in such projects

Christopher Sykes (Construction Products Europe) pointed that prefabrication is not a new sector at all, and a lot of SMEs are already involved. We interviewed Hugo Vigneron from Operene, who explained what his company is doing: Operene is a French company, based in Lyon, working on rehabilitation projects. Their particularity is that they work with SMEs groupings. They organize tender calls, and then involve the right actors to participate. At the moment they are talking with local companies (from Lyon's area) that are wondering about the future of their sector, especially concerning prefabrication. They are looking upon forming a consortium.

Hugo Vigneron also added that it is important for the algorithm and the database in Heart to remain open and also use data from SMEs and smaller providers, in addition to using data from big companies.

If there are still very few number suppliers to be specialized in renovation toolkits for now, the interviewees are confident that more of them will enter the market in the future. If bigger companies have some advantageous (raising funding and larger market access), the role SMEs can play in the sector should not be dismissed due to their local links and expertise.

But a market that still need more structure

A demand side thinking on short-term

For Ulla-Britt Krämer (INDU-ZERO) and Ron van Erck (Energiesprong), the biggest obstacle is that the demand side (e.g. housing associations) is not future-minded, they think about their stock's renovation project by project. They do not look sufficiently ahead in long term to plan their renovation process. Housing associations are reluctant to spend a lot of money at a time for one building, especially since there are no strict obligations in terms of energy efficiency, since this is a responsibility they share with their tenants and residents who are the end-consumers of energy. Both of the interviewees raise the point that housing associations choose sub-optimal step-by-step approaches every 5-10 years instead of one big step for next 20 years. The higher demand level will then lower the costs. The problem is that carbon constraints are real, and we know that dwellings need to reach an A++ target. So why not reaching that goal now, instead of in 10 years? But it is difficult for housing associations to make deeper renovation and to invest so much money at a time. But, for the factories to be successful, they need an order for five years, otherwise they are not profitable. As said before in this document, this is a chicken and egg problem.

The need for a stronger political will

One other obstacle for the further growth of a renovation toolkit market, are the different rules from one country to another. This is an (internal market) barrier that stands in the way of mass-industrializing customized renovation toolkits. Ulla-Britt Krämer (INDU-ZERO) notes that it is important to consider different legal requirements to setup the factory and for the renovation elements. For instance, in the Netherlands, each region has different requirements to build a factory. They also need to look at what environmental and legal impact the factory and the products have, to see if it complies with the legal requirements. This still needs to be investigated by INDU-ZERO.

Janne Rieke Boll sees other barriers on the policy side that limit the development of the market for retrofit toolkits. She would like to have an enabling framework with renovation targets and national renovation roadmaps (that may include step-by-step approaches). Those policy could take the form of financial support from local governments, innovation fund (to create production facilities). New business models need to be enabled if building owners are ready to participate to such innovations experiment, such as the ESCO approach.

To sum up, the main obstacle for renovation toolkits is the fact that it is a new product on the market, and the traditional market and the main (public and private) have yet to accept and promote this approach to use such promising tools at a larger scale.

Going towards more industrialised processes

Are industrialisation and prefabrication a way to lower costs?

For all the persons we interviewed on the supply side, industrialising and up-scaling processes is the future of renovation toolkits. Janne Rieke Boll (BPIE) said that the offer of prefab renovation toolkits could help lower construction costs and overcome the limited supply of skilled workers in the construction sector.

Ulla-Britt Krämer took the example of the project she is working on, INDU-ZERO, saying that INDU-ZERO is facing difficulties at this state in their production model: the problem is that the volumes are low and the costs high. One of the solutions is high-teching, industrialising and automating the production of renovation packages. They are creating a blueprint for a smart renovation factory. She added that lots of factories are focussing on new builds. Renovation is looked down upon because it does not make a lot of money. INDU-ZERO wants these investors to see a business opportunity and their project should be a kind of catalyst to accelerate the supply of such renovations.

Hugo Vigneron (Operene) tempers this idea by adding that the main issue is that, today prefabrication is too expensive to be deployed at a larger scale. It is nearly impossible to implement them without subventions. Prefabrication construction works have always been justified by other constraints: occupied site, need for a rapid renovation, etc. But today it is too expensive to be implemented without any particular reason nor subvention.

A saturated renovation market

Rehabilitation is in all of the European recovery plans. The problem is that many rehabilitation companies are already fully booked, and these incentives to resort more to them runs the risk of saturating the sector. However, for Hugo Vigneron (Operene) and Janne Rieke Boll (BPIE), toolkits are a way to alleviate the problem of the saturation of the renovation sector.

Considering the practicality of prefabrication

Another obstacle to prefabrication is the geographic location of buildings. As Christopher Sykes points out, practically, it is not possible to implement prefabricated solutions everywhere. In lots of cities, the access is too complex to bring large prefabricated elements to renovate buildings. The mentality of the local market is also important.

Pros and cons of monitoring

Monitoring could increase the comfort of housing

For Ulla-Britt Krämer (INDU-ZERO), the algorithm part of HEART could be interesting for monitoring, smart-aspects, prediction, storage (not in INDU-ZERO), user interfaces (not yet in INDU-ZERO). It would be ideal if the system is able to ‘talk’ to the different elements. Janne Rieke Boll (BPIE) adds that other benefits are the increase in health and comfort of people. Projects should be able to monitor those benefits to monetize them and increase the business case. It has been done in other projects, and it could be useful to have more data and increase the business-case.

Staying ahead of innovation

However, with this comes another challenge: staying ahead of innovations. For Ulla-Britt Krämer, product innovations in this sector are really quick, and by the time they are put to mass-production they might already be old-fashioned. That is why such factories will need to be flexible to adapt to innovations.

What is the goal of the algorithm?

Another question has been raised by Hugo Vigneron (Operene): what is the algorithm's priority: saving money? Consuming less CO_2? Something else? This will impact the algorithm choices when choosing materials, and when managing the building, so it is important to consider it in advance. Ideally, the housing provider should be able to run different scenarios based on their own preferences and the prevailing EU, national, local targets.

Making sure the data is used and usable

Eventually, Christopher Sykes (Construction Products Europe) is sceptical about the real use of data. For him, data is rarely used well once it is produced. Also, nowadays data is on every producer's website, some will make it accessible and some will not, but there is no standard. Moreover, the data is published at various formats, that are more or less usable. Working on unifying formats is an important point. At the moment, work is being done to facilitate optional machine-readable product information: Smart CE (CEN website).

Using an algorithm to monitor a building is not something widely used, especially in housing buildings. So, it can be an asset for HEART if the algorithm is easily usable and have a defined purpose.

The example of INDU-ZERO's market analysis

In addition to the interviews, some research was done about INDU-ZERO's own market analysis, because this project is complementary to HEART.

An important step for INDU-ZERO project is to clearly define the market potential for the project, and the business case ensuing from it[5].

To create a business case, the INDU-ZERO team scheduled meetings with housing associations in the Netherlands to create a portfolio of the demand side and see how many dwellings needed to be renovated. Then they analysed what can be done so housing associations would order renovation packages from renovation factories such as INDU-ZERO's. The price of the renovation is an important factor for housing associations in their decision to purchase a renovation package or not. So, it is crucial to demonstrate that renovations like INDU-ZERO can cost half of the current price. That way, there will be less resistance to get a signature from the board for a big amount of renovation orders a year.

They also consulted experts to study what were the strengths of the project and how to be more attractive on the market. Among other they interviewed two companies (Itho Daalderop and De

[5] https://northsearegion.eu/indu-zero/newsletter-update/business-case/
https://northsearegion.eu/indu-zero/newsletter-update/market-potential/

Groot Vroomshoop - a royal VolkerWessels company), as members of INDU-ZERO Advisory board. Both agree there is a big market potential for sustainable renovation packages. The only way it could be financially profitable and trigger a big transition to a sustainable future is to look for large scale solutions like INDU-ZERO.

The social housing sector is interesting for this project because housing associations can buy renovation packages in large mass. The other strength of INDU-ZERO is that it gathers the expertise of 6 countries. With both strengths the project can show other investors that it is possible to renovate dwellings with prefabricated packages, for a low cost, thus motivate them to invests in such projects and generate a bigger market for renovation packages.

Projects such as INDU-ZERO can be interesting for social housing companies because the renovation packages allow inhabitants to stay in their homes during the renovation, so no relocation is needed, which is a plus for countries where the social housing stock is shortage. Also, the project aims at reducing the cost of the renovation by 50%.

On the other side, they also raised points to be careful about: first retrofit measures that social housing companies might have already invested in, as they could hamper the results of the prefabricated renovation packages or cause additional works on the sites, then the diversity of the housing stock in some countries that could hamper the economic benefits of reproducibility regarding prefabrication. However social housing is characterised by more identical dwellings, so the market potential for this housing stock is larger.

Finally, the INDU-ZERO team has conducted an analysis on the market potential of a social housing company in Ghent with almost 2.077 buildings (i.e. 10.000 units): “To roughly estimate the potential, a feasibility analysis was executed considering the year of construction, the frequency of quasi-identical dwellings, the presence of energetic characteristics (e.g. roof insulation), wall insulation and/or double glazing, and the complexity of the building geometry (e.g. the presence of balconies, overhangs).

This analysis showed that 45% of the sample shows potential to be renovated through prefabrication, of which 53% are terraced dwellings, 32% are semi-detached dwellings and 16% are apartment buildings.” They have also calculated how much it would cost for the Netherlands to achieve EU’s target that all buildings should achieve zero-energy by 2050, and how much they could save with the INDU-ZERO project. They show that the project represents € 24 billion/year of additional activity for the economy.

3.2.3. Conclusions from the interviews

3.3. STATE OF TECHNOLOGY AND RELATED PROJECTS

Another part of this research was the benchmarking of other existing projects to understand what is already present on the market, and how HEART could differentiate itself from other projects.

Energiesprong

Goals: Bring about desirable, viable net-zero energy refurbishment solutions to the mass market by 2020. Both a whole house refurbishment and a new build standard and funding approach.

2 dimensions:

- Energy retrofit using technologies such as prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations. Allows a complete renovation of a building in less than 10 days. This renovation is financed by future energy cost savings. For social housing: tenants pay the housing association an energy service plan which is the equivalent of their previous energy supplier bill. The housing association can use this new income stream to partly fund the renovation works.
- New funding approach: establish the right market conditions for the wide-scale introduction of net zero energy homes across Europe. The idea is to create mass demand for these high performance and affordable retrofits. In parallel, Energiesprong market development teams work with regulators to tune policy and regulation, and with banks to create financial arrangements to make a viable path to scale.

Key ideas: create a mass market for energy retrofits, net zero energy houses at a larger scale, create an industry which can design, produce and deliver whole house retrofits with excellence across millions of houses.https://energiesprong.org/

INDU-ZERO

Goals: Design a factory that can produce renovation packages at an industrial scale. Develop a blueprint for a fully automated factory within three years, based on Smart Industry and Circular Economy.

The packages will contain various components that are necessary to make homes sustainable, such as insulation material for walls and roofs, heat pumps, solar panels, energy converters and ventilation systems. If those technologies already exist, the production volumes are too low, and the production costs are too high. A smart renovation factory will make it possible to manufacture those components faster and with a lower price. It also allows to upscale renovation manufacturing such that the pace goes up and the costs go down.

Key ideas: blueprint smart renovation factory, renovation of 22 million houses in the North Sea region, lead investors, housing owner associations, municipalities, governments to bring about initiatives that will result in the needed factory developments, lead to a mass market uptake of home renovation packages. https://northsearegion.eu/indu-zero/

BAMB

Goals: Buildings as material banks. Buildings as "Material Banks" is seeing the buildings as repositories or stockpiles of valuable, high quality materials that can easily be taken apart and recovered. Through design and circular value chains, materials in buildings sustain their value.

The tools that will enable the shift: Materials Passports and Reversible Building Design.

- Materials Passports developed in BAMB are sets of data describing defined characteristics of materials in products that give them value for recovery and reuse.
- Reversible Building Design is design of buildings which can be easily deconstructed, or where parts can be removed and added easily without damaging the building or the products, components or materials.

Key ideas: increase the value of building materials, growth in building material circularity, change in the building business model. https://www.bamb2020.eu/

ReCO2ST

Goals: Residential Retrofit assessment platform and demonstrations for near zero energy and CO_2 emissions with optimum cost, health, comfort and environmental quality.

3-step approach to building renovations:

1. Interactive refurbishment assessment tool (RAT): provides the customer with clearly defined, user-driven refurbishment scenarios
2. Integrated project delivery (IPD) tool: plans and optimizes the installation
3. Selected refurbishment package (at least five components required) of innovative technologies is deployed as a customizable Retrofit-Kit
4. Technologies in the toolkit: cool roofs and cool pavements, Cooling Evaporative effect Ventilated Façade, Intelligent Energy Management System, Heating Ventilation and Air Conditioning Systems, Nature based technologies, Photovoltaic-Integration, Smart Windows, Vacuum insulation panels.

Key ideas: refurbishment customized to end user needs, refurbishment planning to reduce the tie, cost and complexity of the process, NZEB refurbishment in a wide variety of refurbishment scenarios. https://reco2st.eu/

BIMERR

Goals: BIM-based holistic tools for Energy-driven Renovation of existing Residences

Design and develop a Renovation 4.0 toolkit which will comprise tools to support renovation stakeholders throughout the renovation process of existing buildings.

Various tools:

- An automated creation of enhanced building information models
- A renovation decision support system
- A process management tool which will optimize the design and on-site construction process

- An interoperability framework among BIMERR tools with third-party legacy ICT tools to enable seamless BIM creation and information exchange among AEC.

Key ideas: enhanced building information models, process management tool, decision support system, interoperability framework. https://bimerr.eu/

Drive 0

Goals: Make deep renovation environmentally friendly, cost effective and more attractive for consumers and investors. The goal of the project is to speed up the deep and circular renovation process. Circular deep renovation is based on 100% life cycle renewable energy, and all materials used within the system boundaries are part of infinite technical or biological cycles with lowest quality loss as possible. The project also aims at transforming the market for deep renovation of buildings, both in terms of innovative technical solutions, innovative construction processes, combined with process optimization and digitalization (with BIM as a main carrier) and innovative business models. The third dimension of the project is that the renovation must be consumer/end-user centred, in particular by leaning on specific local socio-economic and/or technical drivers as an accelerator.

The process is organised in 4 main elements and steps:

- Benchmarking: both on the potential for circularity as on the *status quo* on drivers for deep renovation.
- Concept development: developing a morphological design approach for circular renovation; the DRIVE 0 industrial partners will develop blueprints of new generation of automated BIM controlled production lines for circular prefab renovation products. This will result in several tailor-made renovation packages.
- Attractive and understandable information for the inhabitants: monitoring of energy, comfort and IEQ and translating the data into understandable information including guidance and tips.
- Demonstrations & evidence: demonstration cases.

Key ideas: supporting consumer centred business models, developing circular deep renovation solutions. https://www.drive0.eu/

Plug-n-harvest

Goals: design, develop, demonstrate, and exploit a new modular, plug-n-play concept/product for ADBE (Adaptable/Dynamic Building Envelopes).

This project transforms static building envelopes to active ones by deploying off-the-shelf energy harvesting, storing and thermal comfort. The different elements can dynamically adapt to available exogenous energy assets.

Four dimensions:

- Adaptive Dynamic Building Envelope (ADBE): consisted by flexible aluminium façade design with high insulation layer and energy-harvest enabling elements,

- Interconnected Elements Ecosystem (IEE): interconnection of existing and new sensing and controllable elements within a unified network,
- Security and Safety Mechanisms (SSM): consisted by safety and security preserving elements forming an encrypted, ICT-based shield for the acceptable operation of the developed digital modules of PLUG-N-HARVEST,
- Energy Management Systems (EMS): consisted by interoperable ICT-based energy management tools at building (IMCS) and district scale (DRFFO and OEMS).

It is also designed and implemented considering circular economy principles. Five Circular Design Requirements (CDR) have been defined to develop the Plug-N-Harvest Façade Modular Kit: use safe materials, think in System circularity, preserve transparency and traceability, keep track of valuable material, rethink business model / New Partnership models / implement business models that support a circular transition.

Key ideas: use the modular, plug-and-play concept to enhance both incremental renovation toolkits and achieve a higher circularity performance.

MORE-CONNECT

Goals: Development and advanced prefabrication of innovative, multifunctional building envelope elements for modular retrofitting and smart connections.

Prefabricated multifunctional renovation elements which have the potential to reduce costs, reduce the renovation time (5 days) and disturbance for occupants and, at the same time, enhance quality and performances (both in terms of energy efficiency as indoor climate).

One of the main innovations of the project is that the elements are tailor-made renovation concepts, although they are from a standardized industrialized manufacturing and assembly process. Also, they have defined five geo-clusters in Europe, that illustrates trans-national areas where strong similarities are found in terms of climate, culture, construction typologies and other factors.

- Product innovation: sustainable materials and sustainable detailing based on LCA, including recycling of materials, biobased materials, flexible, disassemble, and the use of secondary materials. Low embodied energy will be a criterion in the design and development.
- Process innovation in three steps:
    - Use of advanced geomatics to make inventories and gauging of buildings and buildings stock.
    - Web-based and/or digital decision tools will link building characteristics, building (energy) potentials, end-users demands to program requirements, technical solutions, component combinations in concepts, production automation.
- This will be processed in BIM systems for the steering of industrial processes and for enhanced quality assurance.

- Business models and advanced energy services (one-stop-shop) will be developed for each geo cluster.

Key ideas: modular renovation elements, geo-clusters, sustainable materials, communication between components, industrialized manufacturing, one-shop-stop concept. https://www.more-connect.eu/

P2Endure:

Goals: Plug-and-Play product and process innovations for energy-efficient building deep renovation. The main goal is to provide scalable, adaptable and ready-to-implement innovative PnP prefab solutions for deep renovation of building envelopes and technical systems. The project also tackles the urgency to increase the scale and level of adoption of prefabricated rehabilitations through innovative combinations, processes and supporting ICT tools.

Finally, they address the issue of housing shortage: they start by observing that a large stock of public buildings (including office, public service, commercial and historic buildings) has become vacant since the beginning of the economic crisis in 2008. Maintaining the vacant buildings is a critical financial burden for public authorities but demolishing them is often not possible due to high costs as well as critical safety and environmental issues. Therefore, deep renovation with transformation of obsolete public buildings into dwellings is the most effective solution to meet the targeted 60% reduction of energy use with the lowest environmental impact and the largest contribution to solving the housing shortage.

The key innovations of the project:

- Upscaling and EU-wide implementation of prefab Plug-and-Play (PnP) systems
- 3D-printed components, 3D laser and thermal scanning for historical buildings
- Building Information Model (BIM) for deep renovation
- "4M modular processes" (Mapping – Modelling – Making – Monitoring) for rapid and low-disturbance on-site assembly.
- Prioritizing prefab systems that are developed, manufactured, and delivered by European Small and medium-sized enterprises (SMEs)

Key ideas: deep renovation of vacant buildings, upscaling the scale of prefabricated rehabilitations, Mapping – Modelling – Making – Monitoring, 3D scanning and 3D printing, prioritizing SMEs. https://www.p2endure-project.eu/en

Those are a few examples of projects that offer renovation toolkits. They mainly follow similar goals as HEART: make net zero energy buildings by renovating already existing buildings, extend the projects to a larger scale, automatize, and industrialise fabrication processes, etc. It shows that there is an already existing market for HEART to develop its solution, and that this market is growing. Also, it is interesting to study some of the previous projects to be able to complement them/coordinate with them, as HEART has similar objectives. It could be interesting to study their

business plans, because it could be similar to HEART's, or they or they could lead to the creation of a market for HEART.

3.4. OTHER OPPORTUNITIES AND BARRIERS

Finally, some topics weren't addressed during the interviews, and are important to point out to have a better understanding and overview of the market. As Energiesprong is a similar project to HEART that is the most advanced at the moment, it seemed interesting to look at their own market analysis. Here are the points from this market analysis that could be interesting for HEART[6].

3.4.1. Defining a suitable market

- *Start with front runners:* if the front running housing organisations ask for HEART-like solutions, financiers will re-evaluate the financial opportunity and front running solution providers step up and invest in the innovation process. Once these refurbishments are delivered at scale, mainstream consumers will see these packages as proven technology.
- *Start with the right stock*: high proportion of domestic dwellings were built after World War II. The majority of these dwellings have little historic or aesthetic value. In addition, they suffer from poor energy performance and are in need of upgrading both to improve their energy performance and their visual appeal. So, it presents a secure investment for a housing provider. Once solution providers start developing more concepts for different typologies and have flexible factories to fabricate packages, the ability to apply a greater amount of flexibility will increase, enabling to produce solutions for houses with more diverse characteristics.
- *Include the collective (social) housing sector:* to change the dynamics in the market, the initial scale of demand is essential. It is easier to organise sufficient initial demand that can be steered in asking for the same kind of propositions when working together with housing organisations than in the private market. Once the technical concepts and performance-based contracting have been developed, using the social housing organisations' stock, it is much easier to penetrate the private housing market.

3.4.2. Potential Barriers

Procurement and contracting barriers

Depending on the country, housing associations are subject to national versions of the implementation of EU public procurement rules. Such an obligation forms a hurdle when trying to kick-start an early market, where there is much more need for a dialogue and a collective deal making structure in order to reduce risk and work through challenges together.

Fragmented supply side

[6] "Transition Zero Make Net Zero Energy Refurbishments for Houses a Mass Market Reality. Deliverable 8.4 Report on Market Assessment and Bottlenecks"

The classical division of tasks and responsibilities between construction companies, technical consultants, architects, developers, and industrial component suppliers result in high transaction and construction costs coupled all too often with poor quality delivery.

Lack of trust in the whole value chain from industry through to end user

Terminology such as "modern methods of construction" or "prefabrication" are often viewed with suspicion due to historical associations with insolvency risk, poor technical or quality issues, and a need to collaborate early by committing to a specific technical solution rather than follow a traditional sequential tendering process and choosing the lowest price based on an "apples with apples" comparison.

3.5. OUTCOMES OF THE HEART WEBINAR

On September 22nd, Housing Europe held the HEART webinar on 'Pre-fab and integrated renovation toolkits: an opportunity for a Renovation Wave in Social Housing? A HEART project webinar for housing practitioners and policy makers.' Different speakers from the demand and supply side shared their views with the HEART partners regarding the feasibility of renovation toolkits[7].

The outcome of the webinar confirmed the views presented above. The discussions highlighted the importance of several factors: the importance of the social housing sector as a test field for this kind of renovation, the benefit of toolkits in simplifying the renovation process, and the need to scale up the renovation process to meet the European goals.

First, it was pointed out by several panellists that social housing is an optimal test field for renovation. Indeed, one of the main hurdles in reaching the renovation goals in the rest of the residential stock is the heterogeneous ownership of dwellings, as it is complicated to make people agree on renovation. Social housing collects the different needs, and can push for further innovations. It is also leading the path for organisations to develop solutions that then become attractive and mature for private home owners/landlords at a later stage. Another point that was discussed was that the investment horizon of social housing is aligned with the extended lifetime of assets and renovation investments. Therefore, it is easier for stakeholders with a long-term investment perspective to support the investment for renovation, rather than going to individual owners, let alone tenants.

The panellists also agreed on the benefits of renovation toolkits in simplifying the renovation process. Indeed, it is not easy for people living in individual housing to do something about energy consumption, and renovation is a complicated process, with no guarantee of performances. The idea with renovation packages is to have all the elements designed to work well together and to provide a certain performance, and available to buy all at once, like buying a kitchen in IKEA for instance. Renovation toolkits can also help housing associations making better decisions when renovating buildings. Indeed, one of the problems they face is matching the different pieces of renovation technologies to a particular housing archetype. Renovation toolkits is something that could help housing associations deciding what is the best solution for a particular property.

[7] See the programme in the Annex

Another point the panellists agreed on was that there is a need to scale up the renovation process all over the EU. However, if technical solutions to reach this goal already exist (as it was said by Melius Homes, EnergieSprong and INDU-ZERO), there is a need to scale-up and industrialise the whole renovation process. Indeed, in order to avoid the "chicken and egg" problem, there is a need to have all the different players on board. This means that the housing associations, the construction/installation companies, and municipalities/legislations need to be ready as well. Only if all these stakeholders are on board and on the same page, then scaling-up will be possible.

Some interrogations rose during the webinar. The first one was about the possibility to use renovation toolkits in an incremental way, instead of one deep renovation in one time. The incremental solution seemed interesting to consider, first because it allows to invest over the time instead of a big amount of money one time, which can be difficult for housing associations. Then doing smaller renovations will disturb less the tenants. And finally, because technology is always evolving, and a new and better solution can arrive on the market before the end of the retrofit. Then, it may be beneficial to do an incremental retrofit to adapt the renovation to the innovation. One of the key points is whatever is done in the different increments it should not undo the work that has already been done.

Another interrogation was about the costs benefits of using renovation toolkits compared to more traditional renovations. When thinking about the renovation cost, it is important to keep two things in mind. First, renovation toolkits guarantee energy performances, which means that it gives a guarantee on future energy savings. So, during the lifetime of the dwelling, there is more money available. It is interesting to have to look at the cost in a way of what can be saved and what can be financed from those savings, compared to the alternative. Second, when looking at the amount of work that needs to be done to renovate the stock, and the composition of the craftmanship sector, in the next 20 years, we don't have the available resources to scale the retrofits with a traditional way. And when resources are scarce, prices go up. On the other hand, with industrialisation prices automatically go down. Therefore, to answer the question of the cost of renovation, we have to keep in mind the whole cost, and with a future perspective.

Philippe Moseley (European Commission, DG GROW) concluded the webinar by agreeing that there is a need to renovate the housing stock, and for that the construction industry needs to step up to the mark. The European Commission is involved on those questions as it is carrying various studies about what can be done with the digital transition to facilitate more circular economy principles. For instance, there is an ongoing study on the use of digital building logbooks, which are common repositories for all relevant building data, and which would facilitate transparency and inform decision making. The upcoming "Horizon Europe" program will also have an important public/private partnership which will try to scale up innovations and try to get all the players to work together.

4. CONCLUSIONS

During the series of interviews, the desk research and the final webinar, three common themes appeared to emerge more often. These are summarized below and put into the perspective of that HEART Toolkit to inform the further development and relevance of such renovation toolkits.

Prefabrication of renovation toolkits is key, but the market is not mature yet

Demand side	Supply side
• Industrialisation can reduce costs of renovation, and energy consumption. • Industrialisation and a strong local economy can be compatible. • Social housing is a key actor for renovation toolkits because they can commit to certain volumes and a share of the stock is relatively uniform and therefore suited. • Renovation toolkits need to be made cheaper to allow large orders.	• To scale up cost-effective production, the minimum scale to produce renovation toolkit facilities is estimated between 50.000 renovations/year and 70-80.000 renovations/year. • Providers are not necessarily big companies and often include smaller innovative start-ups, SME's • The biggest obstacle is that the demand side (e.g. housing associations) is not future-minded, they think individually about their own stock's renovation project by project

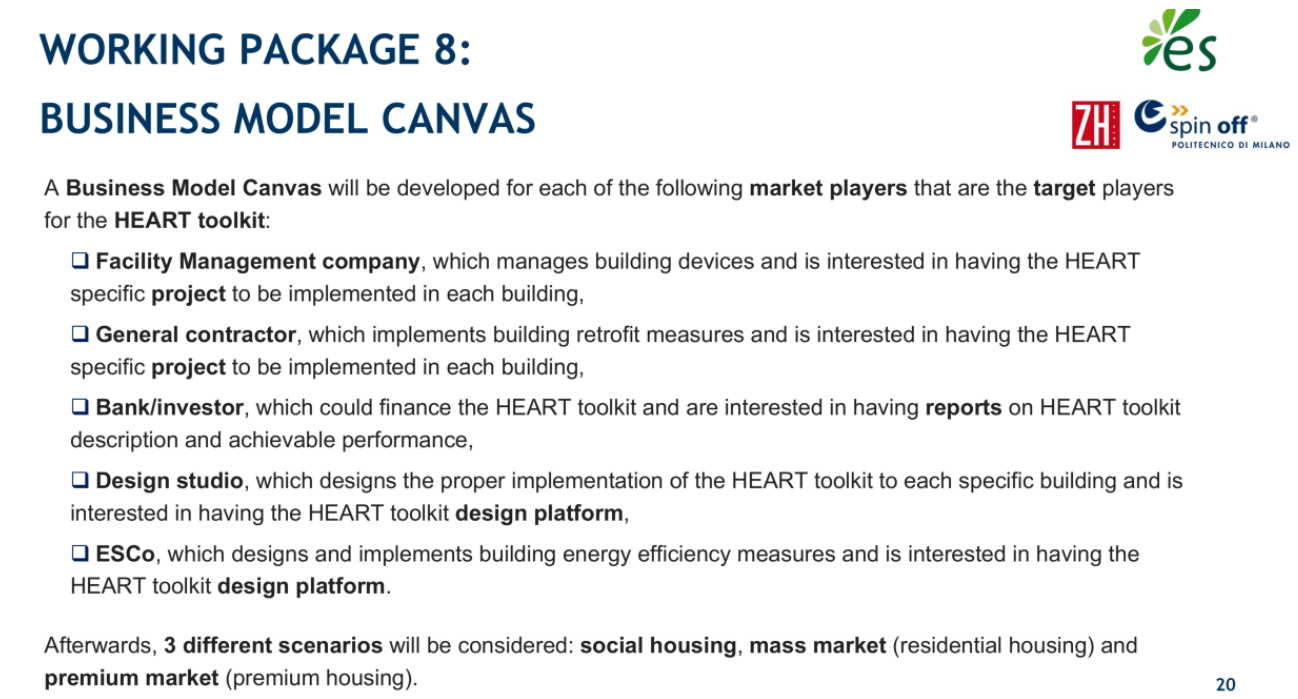
The toolkit should be adaptable to different buildings and situations

Demand side	Supply side
• Industrialisation of rehabilitation processes usually lacks in adaptability, making it difficult to implement on a broad ensemble of buildings • There is a need for a diversity of supply, different kits, like different car models/options. • Incremental options to respond to step-by-step approaches are needed as well.	• Different types of buildings require different types of renovation • It is not possible to implement prefabricated solutions everywhere. In some urban areas, the access is too complex to bring large prefabricated elements to renovate buildings.

A cloud-based algorithm is a powerful element for renovation toolkits

Demand side	Supply side
• HEART's algorithm is seen as a data base to better understand housing stock • The algorithm allowing to have a feedback on performances in a real plus.	• Monitor and monetize health and comfort benefits for people in order to increase the business case • What is the algorithm's priority and who controls it? (Saving money vs saving CO2 vs increasing comfort/health) • Make sure the data is uniform and usable

5. ANNEX



Agenda webinar 'Pre-fab and integrated renovation toolkits: an opportunity for a Renovation Wave in Social Housing?' 22nd September 2020

09.50 Connection

10.00 Welcome and introduction of the HEART project, Claudio del Pero, POLIMI (IT)

10.05 Presentation of the Report, Marion Brunet and Sébastien Garnier, Housing Europe

10.15 Business opportunities for renovation toolkits? Davide Chiaroni, POLIMI (IT)

10.20 Facing the challenges involved in the development and supply of renovation toolkits

- Moderator: Abderrahim Khairi, Housing Europe
- Robert Lambe, Melius Homes (UK)
- Ulla-Britt Krämer, INDU-ZERO (NL)
- Ron van Erck, Energiesprong Europe (EU)

10.35 Understanding the needs for renovation toolkits in the social housing sector

Moderator: Sébastien Garnier, Housing Europe

- Gordon Watts, SYHA (UK)
- Christian Krainer, CEO of OEWG Housing, Member of the Board of GBV Austria, Delegate of Austria to Housing Europe and Vice Chair of the HE "Observatory" (AT)

Moderator: Sébastien Garnier, Housing Europe

10.55 Conclusions by Philippe Moseley, DG GROW, European Commission