The Potential of Standardized Envelope Concepts for Retrofitting

Potentiale von standardisierten Fassaden-sanierungskonzepten

Le potentiel spécifique des concepts de rénovation de façade standardisés

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1. Background

Since 2008 -now almost 8 years ago- Gumpp & Maier GmbH has been actively participating in the technological development of prefabricated timber facades for energy retrofitting. After several prototypes, demonstrations, non-research related and large scale projects, this solution is a stable and substantial part of the company´s portfolio and business.

The main built examples range from row houses, middle and large scale housing blocks to schools:

1.- Dolomitenlaan, Rowhouses in the Netherlands (2010-2011):

2.- Peter Schweizer Schule in Gundelfingen (2010-2011)

3.- Residential building in Hannover (2011) with roof-extension

4.- Middle School in Kissing (2012)

5.- Residential blocks in Hochzoll, Augsburg (2012-2013)

6.- Residential Block in Thamesmead, London (2013-2014)

This projects during the last 5 years have all achieved excellent energy performance targets, reducing their heating demand by a factor 10, to between 10 to 40 kWh/m²*y, and have been, from this perspective, a great success. The technical details and the process further developed and adapted to several different context and needs. As in today´s stand, Gumpp & Maier is comfortable by offering a top-performance timber envelope for high energy renovation.
However, we believe that the huge market potential has not yet been achieved, and the solutions, which have been developed to be highly standardized and replicated has not been as widely used as expected. Projects renovated with TES-envelopes are still seen as light-towers and exceptionally implemented. The vast majority of the more than 11 Mio. units to be renovated remain untouched and consuming as much energy as before.
The limitations have shown to be in aspects other than the envelope itself, such as the difficulties during the construction process, the disturbances to the tenants of preparation and finishing phases and the business models. Therefore, the efforts of Gumpp & Maier have been aiming at addressing these issues as to, from the same timber envelope, improve the general performance, competitiveness and applicability of the TES solution. In this line, Gumpp & Maier has participated in the FP7 founded research project iNSPiRe, which is the main focus of this paper.

2. Lessons learned

2.1. The envelope works

The technology of the envelope works, and develops a best-performance product in the market. It is an economical alternative for large scale projects. When well planned and implemented the costs are in line with the expected and the profit margins may be in line with the usual of the industry. An example is Schlägerstr. in Hannover, where the project was financed by a private real estate owner.
The timber envelope can also offer extensions and modify the envelope by for example incorporating balconies or enclosing exterior corridors, thus adding further possibilities to the renovation without changing the renovation system.

2.2. High competitiveness in certain cases

It offers a solution for a very intensive retrofit, and will be more competitive against other types of deep renovations or demolition and new build. Projects where lighter renovation measures such as new windows and add-on-insulation are considered enough, TES solutions will appear as too costly and unnecessary.
An example is Parkview HUB in London, where it was considered that the only other viable option was the demolition and new build, which proved to be around 30% more expensive than the retrofit solution.
Many –but not all- old buildings need intensive renovation measures simultaneously. Services, the envelope, the aesthetics, changes in use, are in such conditions that the owners evaluate demolition and new build as a viable alternative. These properties can be considered to have reached the end of their life cycle. For these scenarios, TES offers a comprehensive overhaul, offering a result as good as new build, but at significantly lower costs.

2.3. Retrofits are complex projects

Building around an existing building adds more difficulties to an already complex planning process. Working with an existing geometry has already been tackled by 3D surveys, but other unknowns and a very complex network of interdependencies make both the planning and the implementation risky.

2.4. Need for retrofitting the building services

The renewal of the water, heating and sewage pipes, and the electric installations has proven to be as challenging as the construction of a new envelope. They often achieve faster the end of the lifetime than the building fabric and have been improved and repaired in several occasions. At this point, a full renewal is the most convenient measure, but can be extremely difficult in an occupied flat.
A method must be found, where the renewal of the building services can be carried out with the same level of precision and speed as the envelope.

2.5. The technology is also applicable for new build

Timber envelopes for new buildings –hybrid construction- are based on the same technology and offer a new business for timber envelopes with an extremely high potential which is not yet fully exploited. The timber envelope for new build offers a fast, energy efficient and cost effective solution, based on the same technology which has already been developed for retrofit.

3. iNSPiRe FP7 Research project

Since the last larger TES-Projects, the company has proposed itself to address the above issues, and has been working on different research programs to tackle them. Gumpp & Maier´s involvement in iNSPiRe has focused on a proposal to renew the building services systematically in combination with the envelope. This in order to enhance the competitiveness by adding more value to the TES method, and offering a more comprehensive solution for building owners.

3.1. Strategic development of the timber envelope

The need to develop an adequate strategy for renewing the building services in TES projects is based on four criteria:

- The timber envelope itself is a costly product in the market of renovation, and there is a need to make it more competitive. A strategic decision is not to try to produce it cheaper, but to increase its value by integrating additional functions to it: deliver more value by multi-functionality.
- Old buildings do not have -with very few exceptions- mechanical ventilation systems, which are considered necessary with current airtight envelopes. Furthermore an appropriate heat recovery is necessary to achieve state-of-the-art energy demand targets.

- Old building have outdated building services: water pipes, heating equipment and devices, sewage systems and electric circuits are at the end of their life cycle and have to be renovated.
- Energy harvesting or generation brings a good opportunity to reduce the overall energy demand and needs to be systematically integrated to the concept.

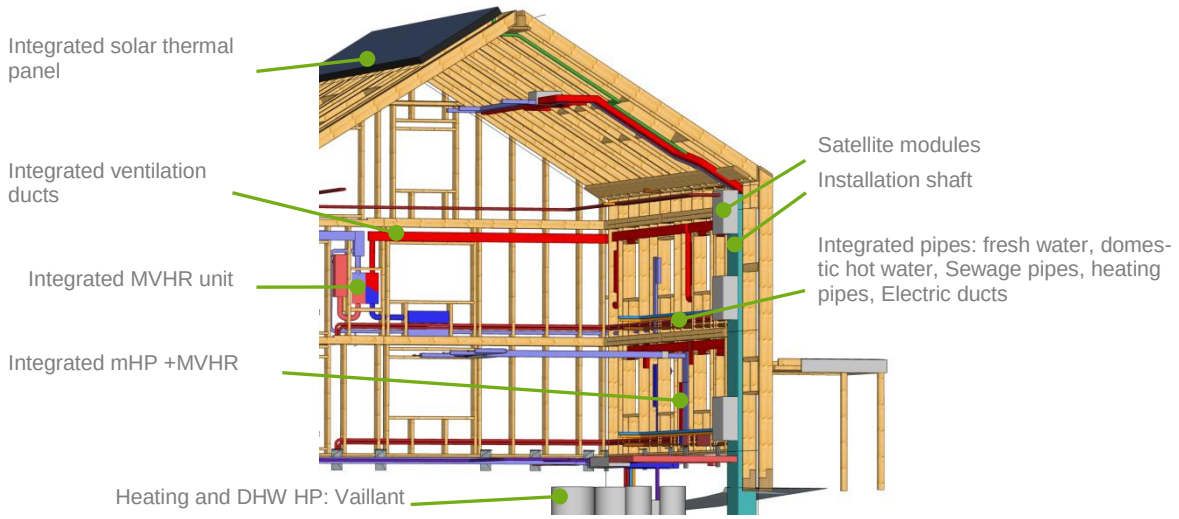

Image 1: Building services integrated along with the TES envelope in the demonstration project of iNSPiRe in Ludwigsburg. Source: Gumpp & Maier GmbH

The project iNSPiRe (2013 to 2016) has set the target to develop technology to reduce the primary energy consumption by systemic retrofitting to 50kWh/m²*y or less. It gathers 24 partners in an FP7 Project founded by the European Union for 4 years (93 man*years of work) to propose, develop and demonstrate technological packages with a high replication potential. The proposed solutions include 6 Kits which can be combined as plug-and-play units to adapt to different climatic conditions, building typologies and needs.
As a timber frame manufacturer and construction contractor, Gumpp & Maier has been developing as a system integrator, where its offer is the result of the combination of different systems and products available in the market.
The innovation strategy of the company is to build up technological partnerships with producers of complementary products and systems, to offer integrated solutions. In this way, the development of the kits aims at integrating functions to the timber envelope in order to improve the overall performance of the TES method for end users.

3.2. Retrofitting kits

Gumpp & Maier GmbH has taken part in the development of three of these KITs:

- KIT 1| timber envelope + Mechanical ventilation with Heat Recovery (MVHR) and a micro heat pump, including all ducts. An alternative is the MVHR system without heat pump.
- KIT 2| new pipes and cables for water, heating, sewage and electricity cables integrated behind the façade and a prefabricated vertical shaft.
- KIT 3| further development of active facades with enhanced integration of PV and solar thermal panels.

Other kits have been developed within the project which can be combined with the above, such as energy hub, radiant ceiling, and passive cooling. In the framework of the iNSPiRe project the kits will be implemented in three demonstration projects in Verona (it), Madrid (es) and Ludwigsburg (de).

The three kits in which Gumpp & Maier has participated, will be demonstrated in the project in Ludwigsburg[1], to which the following descriptions will refer.

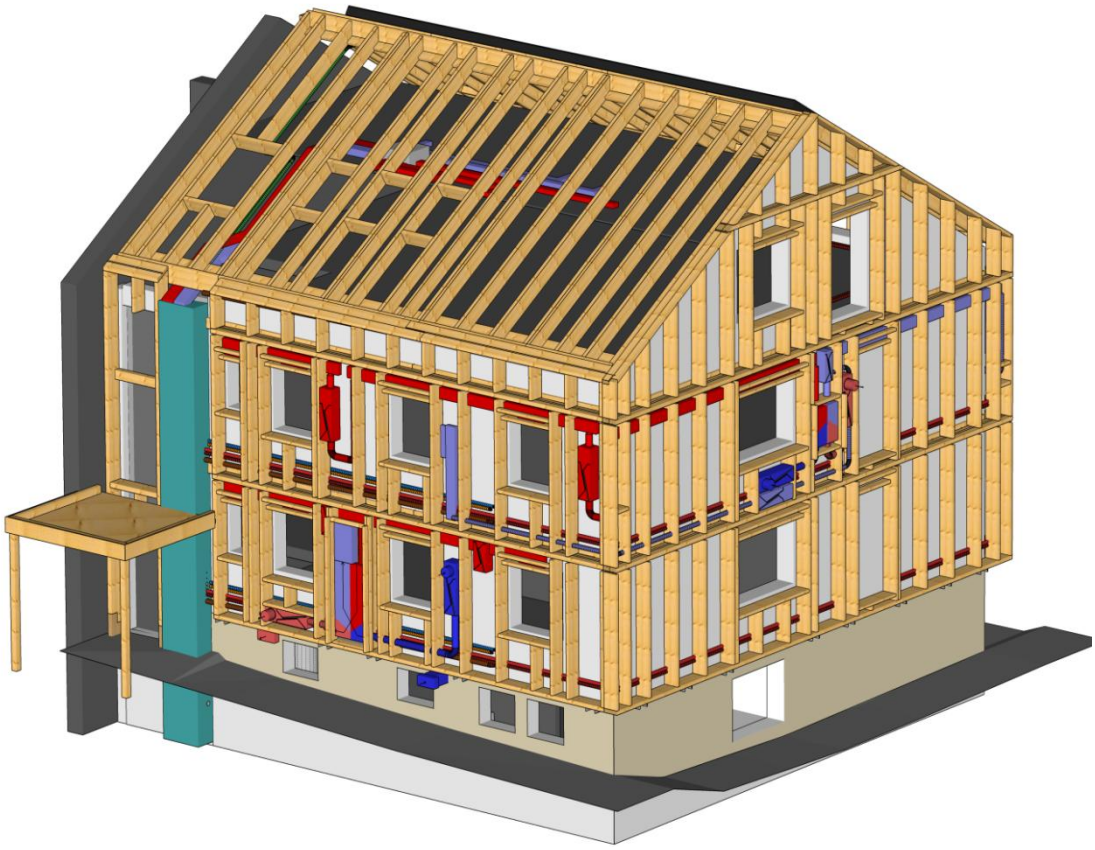

Image 2: Timber envelope with integrated building services. Source: Gumpp & Maier GmbH

3.3. KIT 1[2] | timber envelope + MVHR + mHP[3]

The idea is to integrate as many components and ducts as possible in the prefabricated timber envelope. The installation of these components has proven to be extremely difficult -almost impracticable-in occupied flats, due to the disturbance caused to the tenants. Even if carried out in a flat with cooperative residents, the difficulties of coordination created delays and is extremely time consuming. Because of these reasons, most of the TES projects have been carried out without heat recovery ventilation systems, which limits the effectiveness of the energy renovation.
Air ducts for fresh air intake and exhaust are connected to silencers and installed through the timber structure under the windows. The air extraction is installed above the window openings with a 60 x 200 mm duct (shown in red in image 3), with a grill on the upper cill. Special silencers have been developed to insulate the air system between rooms, in a unit that fits between two timber studs.
The MVHR+mHP unit is installed in the factory, in a compartment reachable from the outside for maintenance and filter exchange. Therefore, it is either installed accessible from the ground floor, or on a balcony wall.

2 Systems have been developed:
- Kit 1a Partial integration with mHP

A heat pump has been added to the MVHR unit peripherally, with the evaporator connected to the exhaust air, and the condenser on the supply air, delivering heating to the

[1] Demonstration Project, Residential building in Karl-Dieter-Str. 24, 71636 Ludwigsburg. Owner (and iNSPiRe partner) Wohnungsbau Ludwigsburg GmbH.
[2] Developed in the framework of iNSPiRe WP3.5
[3] Produced and developed by Siko Solar GmbH, Jenbach Tyrol

flat when the passive mechanism is not enough. The unit delivers some 800 W, which is enough for dwelling renovated to these high performance energy levels. In this case, since the supply air is heated, it is driven directly into the apartment in order to avoid losses from the duct through the fabric.

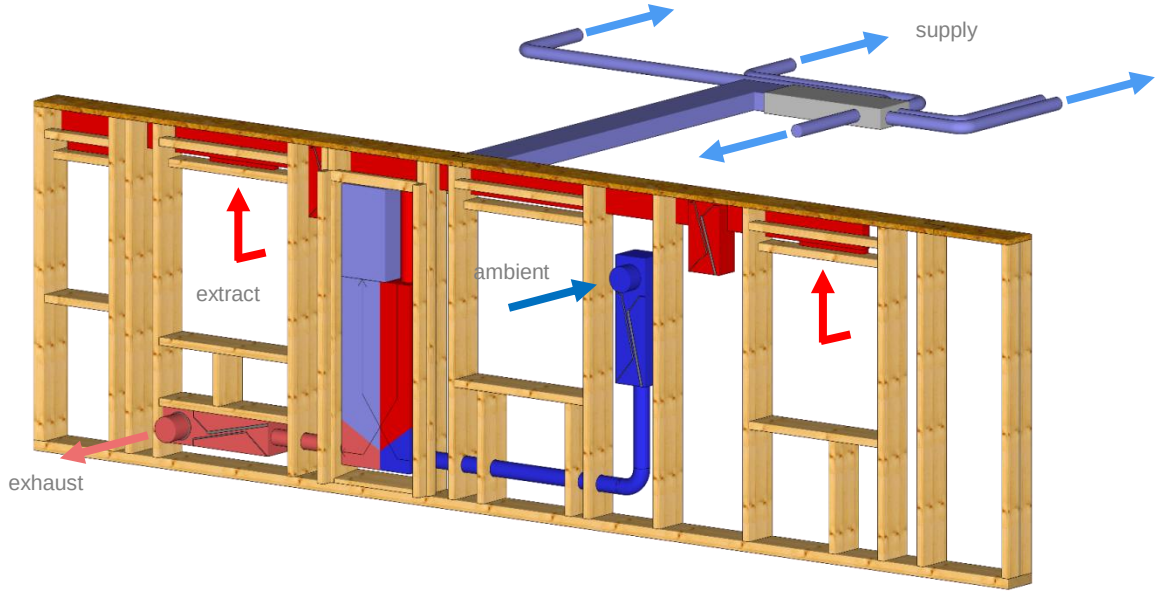

Image 3: Timber element with components of the ventilation system and the air flows. The device in the middle represents the MVHR (Mechanical ventilation with heat recovery) and the integrated micro Heat pump.

– Kit 1b Full integration with all ventilation ducts

When another heating system is installed and no additional heating is planned along with ventilation, all supply and extract air ducts are installed in the timber envelope.
The extract circuit runs through the north façade, where kitchen and bathrooms are located. The supply air ducts are also installed on the window cills, on the south side of the dwelling where the sleeping and living rooms are located. The connections on the corners are done through openings on the cladding, which are closed on site from outside.

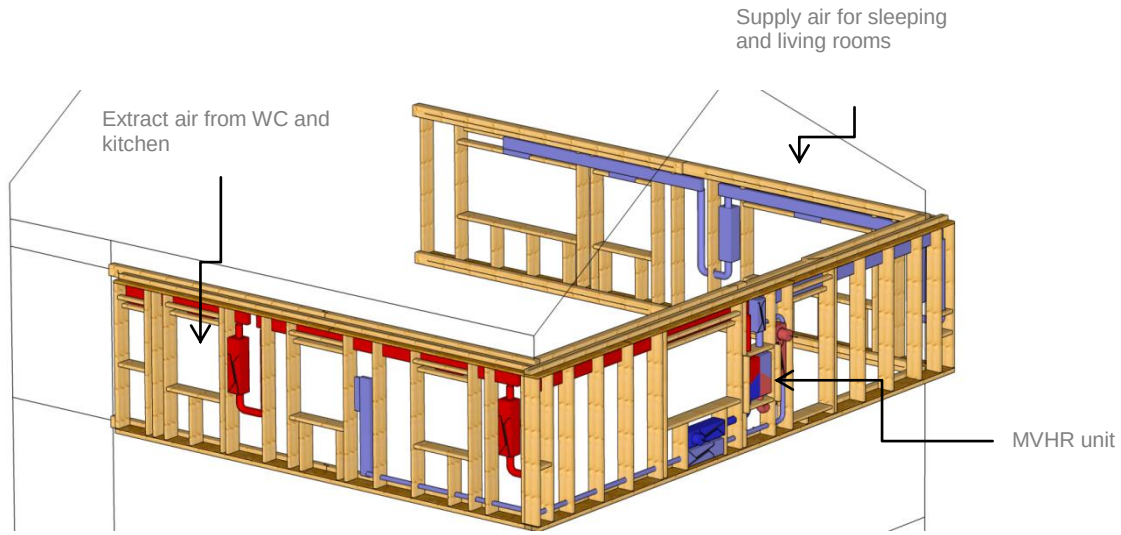

Image 4: Schematic drawing of a flat with full integration of the ventilation ducts, in red: extract air, in blue, supply air. Source: Gumpp & Maier GmbH

Special attention has been given to sound insulation. The MVHR and the MVHR+mHP units are mounted on PUR-elastomer rubbers designed to decouple the vibration from the devices to the timber construction. Additionally, ducts above the windows are in-

stalled on impact sound insulation, to avoid the sound of the air flow to be transmitted through the timber cill into the sleeping rooms.
Regarding fire protection, this project has delivered a solution for building class 3 (acc. To German regulations GK3), where the TES walls have relatively simple fire requirements. If this system was to be planned for higher building classes, a fire separation must be further developed.


Images 5 and 6: Installation of ventilation ducts in the factory. Source: Gumpp & Maier GmbH

3.4. KIT 2[6]| prefab shaft + new pipes behind the façade

The renovation of the building services is also costly and almost impracticable in occupied flats. Therefore, a solution has been developed to install all pipes and cables on the existing façade from the outside, between the existing and the new wall layers. In this way, the installer can finish his works, carry out the necessary tests and finish from the outside before the new envelope is mounted.
The most complex part of the system is the vertical distribution shaft, which is also foreseen in the new envelope, connecting all floors of the building. A timber box is produced in the factory with all main service pipes built in, and connections on the side for a plug-and-play installation of pipes on the facade. The installers on site have to only connect to the box with standard fittings, and fix them on the façade with relative freedom around the building.

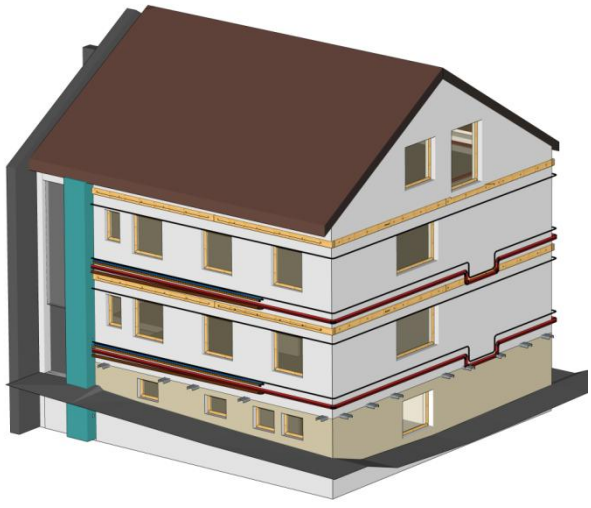

Image 7: Schematic drawing of the demonstration project in Ludwigsburg with the new building services on the façade and the shaft ready for the erection of the TES-Facade. Source: Gumpp & Maier GmbH

The shaft also has strict fire requirements: It must be made with incombustible materials and have a REI rating of 30 minutes (specifically S-30 for shafts). Despite the incombustibility criteria, a timber structure is preferred due to thermal and structural behavior. Therefore an encapsulation with gypsum boards is required to avoid combus-

[6] Developed in iNSPiRe WP 3.3

tion for 30 minutes, additionally to the 30 min rating. This solution requires a special permission from the fire authority, which can be obtained by the relevant consultant.

The penetrations of the pipes and ducts through the shaft walls also have to fulfill a 30 minute fire requirement. For this purpose, a multifunctional product has been chosen, where different water, sewage and electric ducts can be fire proofed in a single flexible system. The fire safety solution is produced in the factory and delivered finished to the site, with the connection outside of it and ready to use.

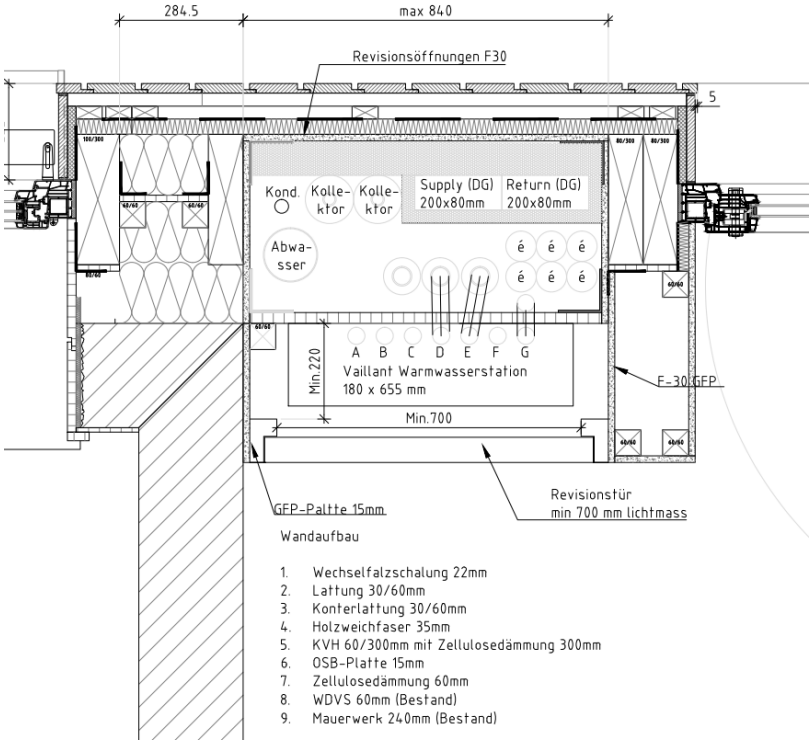

Image 8: Detail of the prefabricated shaft with all pipes and ventilation ducts of the M&E installation.

Source: Gumpp & Maier GmbH

On the façade, the following pipes and ducts are foreseen: fresh water, domestic hot water, heating feed and return pipes, electrical cables (in this case for the new solar protections),and sewage pipes. Additionally, a solar collector pipe and ventilation ducts connect the cellar with the roof apartment. The shaft is installed as a single element on the wall, previous to the installation of the other ducts, potentially saving some 2 weeks of on-site works.

Images 9 and 10: Prefabrication and erection of the shaft with M&E installations

Source: Gumpp & Maier GmbH

3.5. KIT 3[7]| timber envelope + solar panels (PV and ST)

Several has been recently developed regarding BIST (Building integrated solar thermal) and BIPV (Building integrated PV). In this project, the combination has been further developed to improve the aesthetics and reduce overall costs by a rational integration.
Existing systems offer either very few integration, whereas the collectors are boxed mounted on the building fabric. These appear as boxes added to a façade, without the logic or advantages of integration. Other systems incorporate the components of the collectors inside the timber envelope, reaching full integration, but creating issues with maintenance and warranties.
A more simple approach has been developed, where a very thin collector is mounted on the timber envelope as any façade panel. The ventilated air cavity is designed in a way that it provides insulation to the back of the collector, helping to reduce its thickness, and simultaneously allowing vapor diffusion of the construction. The integration simplifies the collectors in such a way, that they can be produced at lower costs, with less insulation, and easier mechanical fixings. The hydraulic connections are designed to be integrated within the ventilated cavity, allowing for a frictionless installation along with the solar panels.
Vaillant GmbH has developed an innovative collector based on the above principles to be integrated to timber envelopes. The solar thermal collectors follow a very clean design, so that they appear to be only glass cladding panels.

[7] Under development in iNSPiRe, WP3.3. The Solar collector has been developed by Vaillant GmbH, and is being tested at Fraunhofer ISE premises.

Images 11 and 12: First sample of the solar thermal collector built in a TES-Façade in the factory.

Source: Gumpp & Maier GmbH

With this strategy, the collectors and the timber envelopes can be produced independently, with separate warranty, maintenance, and easy replacement. The solution delivers optimal aesthetics, lower costs, and a higher degree of prefabrication than the standard systems available in the market.

4. Conclusions

The experience of developing the TES facades from its beginning to the current status has opened several windows, showing new development paths within and outside retrofitting.

We can expect the demand for renovation to continue growing regardless of the political decisions. Current building stocks are and will continue reaching the end of their life cycles, and TES-Facades offers a valuable solution for an intensive overhaul, and an alternative to demolition and new build.

The success of the TES method and its further introduction in the market will depend not only on the quality or success of the envelope, but also on the overall solution it offers for integrated retrofitting. The improvement of the product and its success lies in its capacity to integrate to an overall retrofitting concept which includes all factors which are important for the stakeholders, such as overall construction time, installations, disruption during the whole construction period, reliability of the planned costs and programme, etc.

Prefabricated timber envelopes can offer more, making them more competitive and more attractive as a product, by integrating more functions and systems into or along with them. The advantages of prefabrication can be exploited by simply adding more processes in the factory. The pilot integration of the installation of M&E and ventilation systems in the production line has proven to be an advantage also for specialized contractors, who benefit from an industry environment rather than the conditions of site. By this means, there are potential savings in the overall process in terms of costs and time which are with no doubts convenient in renovation, and possibly also in new build.

One of the most challenging and determinant parts of the prefabrication process is planning. Due to all recent requirements, this task has increased in complexity, often adding friction and costs to production and construction. Planning has become a predominantly coordination task, where the main difficulty is the integration of several specialized planners and consultants. The inclusion of the M&E planners to this task adds complexity. Nevertheless, there is an opportunity to optimize and simplify the overall construction solutions by integrative planning.

Gumpp & Maier and other timber frame manufacturers have gathered experience and expertise on the planning for prefabrication. Their ability to integrate systems can be further developed for multifunctional facades, enhancing their competitiveness and adding more value to their production and product ranges.