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Survey Report on suitable renovation systems for various climates

Preliminary survey report

TASK DESCRIPTION

Undertake a study that investigates the current state of the prefabrication construction systems industry and one-stop-shop system providers and the various products, technologies and methodologies that are available. These renovation construction systems, prefabricated or conventional (but streamlined), will be analysed regarding their thermal performance, thermal-bridge-free connections, airtightness concept and component connection approaches. The outcome will be a survey report of renovation systems that are suitable for reliable and fast deep retrofits in various European climate zones, specifying various characteristics, like the suitability for the application on certain existing construction types (as identified in Task 2.1), the consideration of step-by-step refurbishments or the implementation of either ventilation or renewable energy systems.

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TABLE OF CONTENT :

ENERGY EFFICENCY REQUIREMENTS:

AIM : ENERPHIT STANDARD

- Efficiency properties of The Building Envelope Components (Walls, roofs, Floor Slabs, Windows, Ventilation systems) according to international EnerPHit qualities
- Thermal Bridge Free Connection Details:
- Comfort and Hygienic considerations (mould / humidity)
- Airtightness Concept between elements and connections to existing building
- Provide/Plan for Step-by-Step connections

RES IMPLEMENTATION

- Requirement to allow PV implementation on the south orientated roofs
- PV implementation in the façade

EMBODIED ENERGY CONSIDERATIONS:

Environmental performance of prefab facades can be measured with LCA calculation en detail. Some parameters for the selection of ecofriendly materials are:
• Low or negative GWP per m^2 of ≤ +5 kg CO 2 equiv of an entire closed element without cladding,
• Higher amount of PEren than PEnr (primary energy renewable and not renewable),
• Modularity and Durability,
• Increased ratio of biotic instead of abiotic resources, transport and Application – for prefab/semi-prefab/Conventional [TES energy facade]

DIMENSIONING OF PREFABRICATED ELEMENTS

The cost-effectiveness of prefabricated façade elements generally increases with the spatial dimensions, since fewer work steps per square meter of façade (turning the façade element, etc.) are then required in production.

The dimensions are limited by the following constraints:

TRANSPORT

For prefabricated wooden elements, the spatial dimension is more decisive than the weight of the façade elements (e.g. in comparison to prefabricated concrete elements). For cost reasons, it must be checked in each individual case whether a special permit for transport is not more cost-intensive than smaller façade

elements. According to the German road traffic regulations, the following transport dimensions are possible for precast façade elements with the use of a special **low-loader** as an articulated truck [LeLevé 2016]:

- Without a certificate of exemption:
  - Width: 2,55 m
  - Height: 3,7 m
  - Length (incl. length extension (overhang) of 3 m): 15 m
- With exceptional permission:
  - Width: 3 m
  - Height: 4 m
  - Length (incl. length extension (overhang) of 4 m): 16 m
- Price: 8€/m2 for 250 km distance **[Construire Hors site]**

Further heightening may be possible, but is subject to additional conditions ("exceptional convoy" with police escort). The maximum permissible transport dimensions must be checked on a country-specific basis. (Price: up to 45€/m2 for 250 km distance for 3D modules) **[Construire Hors site]**

Restrictions due to the situation on site
The situation on site may further limit the maximum dimensions of the modules. These include, among others, the access road, access to the site through gates or restricting natural obstacles, surrounding buildings.

Module stiffness
Higher loads on the façade elements are to be expected, especially during transport and when the modules are attached by cranes, for example. Modules with integrated windows are more critical in this respect and are therefore manufactured with smaller external dimensions. This can be remedied, for example, by using transport frames or lifting devices.

Structural restrictions due to the existing building
The conditions of the existing building can further limit the possible module size. For example, roof overhangs can be critical for cases where the existing roof is not renovated at the same time as the façade. One solution may be a combination of different element sizes to allow modules to be installed under the existing roof with smaller elements. Another option is to combine prefabricated modules with thermal insulation composite systems for small-scale façade areas.

s. Requirements anchors and brackets

Installation of the windows

In the course of a minimally invasive refurbishment, the integration of windows, doors and building services into the façade is a key issue. The installation of the windows during the production of the façade elements allows for a closed building structure and thus protection from the weather during the time of the refurbishment (see Figure 1). The existing windows can be subsequently dismantled. For this purpose, an individual appointment can be agreed with the

building occupants of the individual apartments/parts of the building. A disadvantage is the only possible access to the windows from the inside and the resulting need for workspace and dirt in the interior spaces [LeLevé 2016].

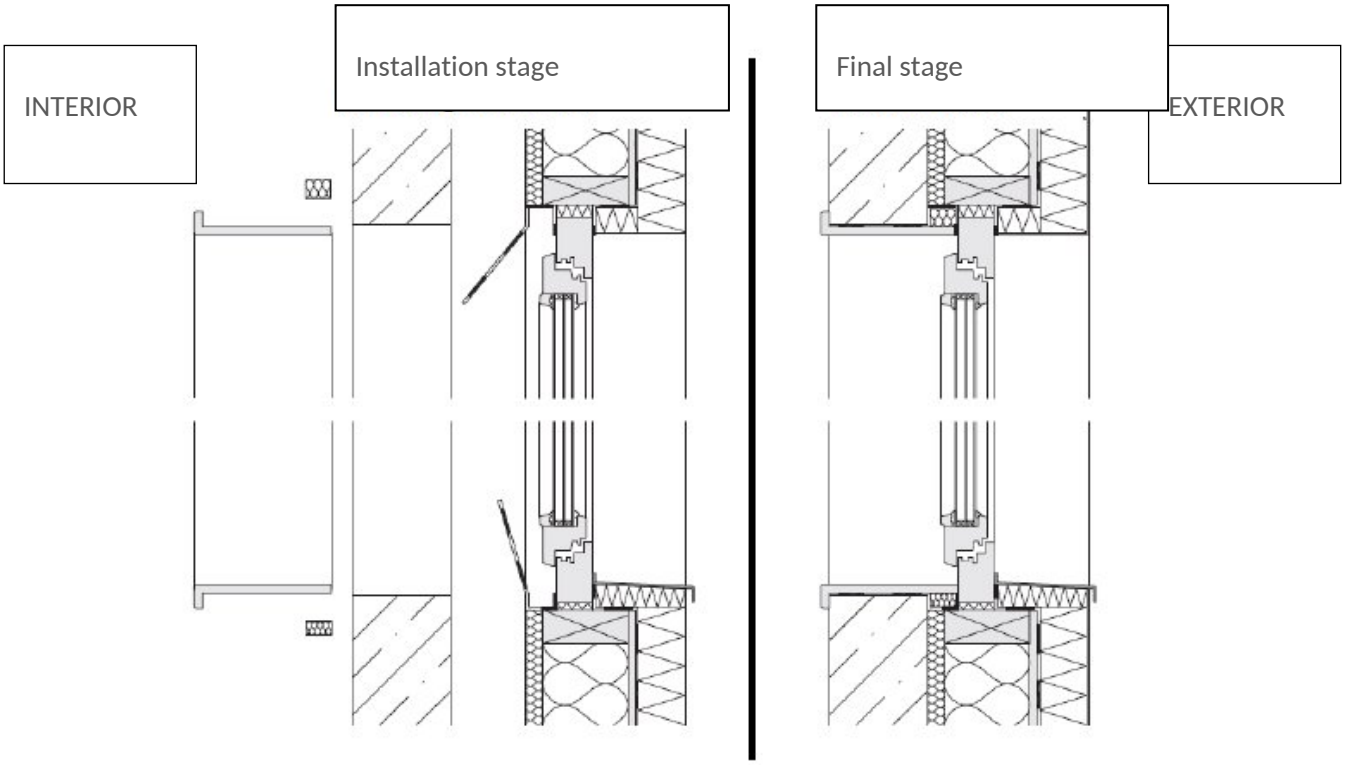

Figure 1: Installation of a new window [LeLevé 2016].

Connection variants of non-load-bearing façade elements

There are various options for connecting non-load-bearing façade elements to the existing façade. The three possibilities "self-supporting facade", "hanging facade" and "adjusted facade" (set or) are shown in.

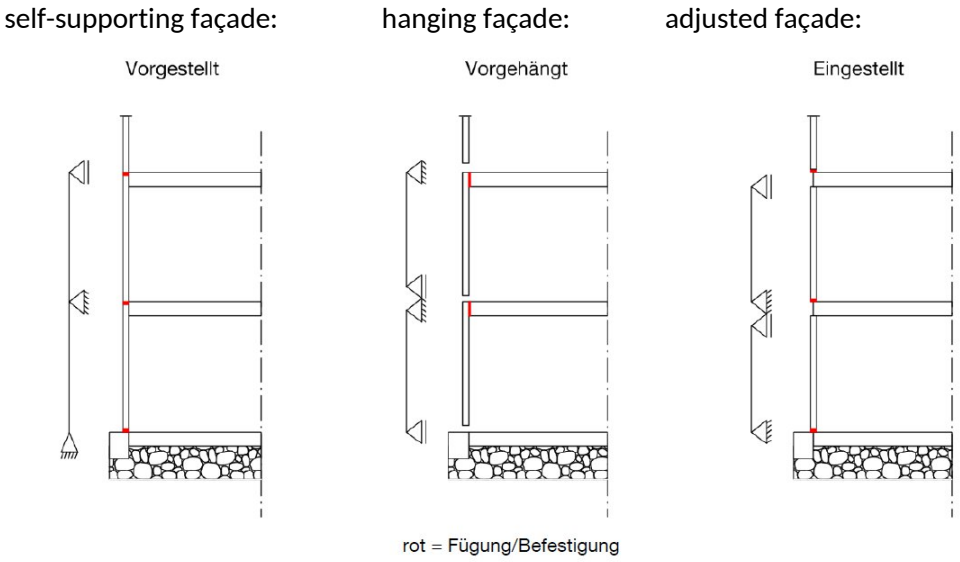

Figure 2: Connection variants of non-load-bearing façade elements [Stein 2016]

The choice of structural system depends largely on the support structure, geometry and materials of the existing building.

The connection variant "self-supporting façade" places lower demands on the existing structure. However, this variant requires an additional foundation and the dead loads of the individual elements are added up across the floors. Consequently, the individual elements are not independently load-bearing or replaceable (e.g., in case of fire). Figure 3 compares further advantages and disadvantages of the connection variants in terms of building physics.

The choice of the system "hanging façade", time-saving system places increased demands on the load-bearing structure of the existing building. This must be precisely measured for the attachment of the anchor points before the exterior façade elements are fastened. As a rule, it is possible to install the anchors in reinforced concrete elements without any problems. In the case of existing masonry or wooden ceilings, project-specific solutions (e.g. use of more façade connectors than for fastening in reinforced concrete skeleton) may have to be developed for fastening.

The connection variant "adjusted façade" is set to integrate in the existing load bearing structure with minimal efforts

	Connection variant "**self-supporting façade**"	Connection variant "**hanging facade**"	Connection variant "**adjusted facade**"

System	independent system in an outer plane outside the supporting structure	independent system in an outer plane outside the supporting structure	Single-span system within the supporting structure per floor
Advantages	Compensation of larger tolerances against dimensional deviations Continuous insulation envelope almost free of thermal bridges Simple installation of the airtight, vapor-barrier layer	Higher kink stability Continuous insulation envelope almost free of thermal bridges Simple installation of the airtight, vapor-barrier layer	Possibility of integrating the skeleton structure within the façade Favourable sound bypass transmission Separation of fire propagation paths with the help of the massive supporting structure
Disadvantages	Increased installation effort in terms of compliance with fire and noise protection	Design of complex connections Increased installation effort in terms of compliance with fire and noise protection	Settlement sensitive system Larger joints to the solid supporting structure for installation reasons Increased risk of thermal bridges Installation of the airtight and vapor-barrier layer difficult

Figure 3: Advantages and disadvantages of the connection variants of non-load-bearing façade elements [Stein 2016].

In principle, vertical mounting of the modules is also possible. This can result in further advantages. With vertical modules, for example, shafts and lines for the building technology can already be integrated into the modules in the assembly hall. Access requirements to apartments for the implementation (technical equipment / windows, window reveals)

s. Maximum weight of glazing elements

- Execution time for wall / roof / technical equipment incl. preparation, execution, post processing

ADDITIONAL ASPECTS

FIRE PROTECTION

The cost-effectiveness of using prefabricated modules compared to conventional refurbishment methods generally increases with the façade area that can be refurbished with the façade elements. For this reason, buildings with at least four full stories are particularly worthy of closer consideration for serial refurbishment. As a rule, fire protection poses the decisive requirements, especially when using structural timber.

In principle, the definition of fire protection targets and test methods is not uniformly regulated throughout Europe. National fire protection requirements must be tested and fulfilled on a project-specific basis.

Prefabricated façade systems can be designed as non-load-bearing exterior wall constructions that are hung or placed in front of an existing exterior wall, or they can be attached to the reinforced concrete skeleton in hybrid construction. In the second case, the entire system, including the existing wall, must be considered in the fire protection assessment [LeLevé 2016].

Load-bearing components of the prefabricated elements must be protected from the effects of fire by encapsulation with non-combustible materials. The reveal area of windows, in particular the lintel area and external venetian blind boxes, represent a weak point of the system and must also be specially protected.

The integration of ventilation ducts in wall modules requires encapsulation with fire dampers where fire compartments are penetrated. Ventilation ducts and electrical installations in wall modules require fire protection partitioning.

The "E.T. façade system" developed as part of the project "Ecological renovation with plastered, prefabricated façade elements in building class 5 with more than 6 full stories" (in German: „Ökologisches Sanieren mit verputzten, vorgefertigten Fassadenelementen in der Gebäudeklasse 5 mit mehr als 6 Vollgeschossen“) with cellulose as insulation material is classified as a complete system according to European standards. This avoids the need to prepare a project-specific fire protection report for each building. The fire behaviour has been classified according to ÖNORM EN13501-1. For the use of the system in high-rise buildings, the submission of a suitable fire protection concept is currently still mandatory. In the research project of the Technical University of Munich "TES-EnergyFaçade", compliance with the fire protection targets for the façade system was demonstrated in accordance with the German test standard. [LeLevé 2016].

If necessary, the use of plant engineering (e.g. automatic extinguishing system) or structural measures (e.g. encapsulation of wooden components) can help to achieve the fire protection requirements.

SOUND PROTECTION

As a rule, better exterior sound insulation can be achieved with prefabricated modules compared to a composite thermal insulation system. Due to the multi-layered structure of the modules, optimization of the component layers with regard to good sound absorption is already possible in the factory.

(Maintenance considerations for embodied equipments)

Daylight, solar radiation gains and overheating protection

Since the window openings in existing buildings tend to allow smaller solar radiation gains than is usual in the construction style of the Passive House Standard, the existing openings should not be further restricted (e.g. by greater reveal shading due to external insulation). With prefabricated modules, it is possible to prepare the reveals already leveled. In addition, the window opening can be enlarged by removing old shutter boxes to increase the amount of daylight in the building. Solar gains can be further increased by placing the windows in the insulation plane. In the case of high solar radiation loads, protection against overheating in summer and the avoidance of glare must be considered at the same time. Shading elements (blinds, PV panels, etc.), as well as devices for automated control (wiring) can be prepared off site at the factory.

COSTS - for prefab/semi-prefab/Conventional

- Cost pro module (dimensions) at factory leave
- Transportation costs
- Installation costs on site (urban, landside)
- Preparation costs of the building
- Maximum cost per m2 of envelope
- Cost for maintenance? Maintenance contracts?
- Comparison to conventional renovation (including quality assurance, providing temporary accomodation, on-site supervision…) (e.g. ask NHT)

COORDINATION OF DESIGN AND EXECUTION - for prefab/semi-prefab/Conventional

- Energy efficiency design and verification
- Application for funding: yeah!
- coordination of execution
- quality assurance of execution
- Blower-Door-Test
- ventilation adjustment
- introduction to inhabitants

ENERPHIT FOR VARIOUS CLIMATE ZONES: COLD, COLD-TEMPERATE, TEMPERATE WARM AND WARM

WALLS:

Insulation	Lambda	Thickness (Cold Climate)	Thickness (Temperate-Cool)	Thickness (Temperate-Warm)	Thickness (Warm climate)
EPS	0,035	200	130	50	10*
stud system with mineral fibre	0,035	200	130	50	10*
prefab panel system with cellulose + 4cm of wood fibre board	0,045 + 15% beams	350	275	100	100
pur/pir insulation (on the attic ceiling / on the roof battens)	0,025	120	100	50	10*
eps insulation on the attic ceiling / on the roof battens	0,035	170	150	60	10*
mineral fibre between battens + 4cm of wood fibre board basement ceiling	0,040	350	250	100	20
pur/pir insulation below basement ceiling	0,025	120	100	50	10*

- * overheating limit reached

THERMAL BRIDGES:

- flanking insulation of app 50cm in each situation

- flanking insulation for balconies

WINDOWS:

Windows	Quality (Cold Climate)	Quality (Temperate-Cold)	Quality (Temperate-Warm)	Quality (Warm climate)
window qualities for glazing	Triple glazing	Triple glazing	Double glazing	Double glazing
window qualities for frames	U_f = 0.6	U_f = 0.8	U_f =1.0	U_f = 1.2
Installation recommandations : position	In the insulation layer	In the insulation layer	tunnel	tunnel
Installation recommandations : frame insulation	Yes	Yes	Yes	Yes
shading concept	optional	Yes: Passive	Yes: Passive	Yes: probably active

VENTILATION:

Ventilation with Heat Recovery or Humidity Recovery	H.R. (Cold Climate)	H.R. (Temperate-Cold)	H.R. (Temperate-Warm)	H.R. (Warm climate)
heat recovery efficiency according to climate zone	> 75 %	> 75%	> 75 %	>75 %
humidity recovery where applicable (very cold / warm and humid)	Not applicable	Not applicable	Optional if humid	Optional if humid
short and insulated ducts with minimal intrusion into flats	Yes	Yes	Yes	Yes

maintenance + condensate drainage issues	Yes	Yes	Yes	Yes

HEATING / COOLING:

- when possible replacement of heat generation with heat pumps instead of fossil fluids

- split units when active cooling needed

SURVEY OF AVAILABLE RENOVATION SYSTEMS:

TESTED AND ANALYSED DURING OUTPHIT PROJECT:

- **ECOCOCON (s. CS 07)** https://ecococon.eu/fr/
  - Not developed for retrofit in initially, but fits ideally on court side wall
  - Spares crane mounting
  - Fabric
  - PHI Certified system

- **TECHNIWOOD (s. OP08)** https://www.techniwood.fr/
  - Developed specifically for mounting complete facades
  - Fits ideally on plain facades
  - Layer count determines efficiency
  - Minergie certified product

- **HUNSINGER (s. CS38)** https://www.hunsinger.fr/
  - Interesting vertical system (vs horizontal ones)
  - Many years of retrofit experience
  - Developed specifically for plain building in occupied mode
  - Fire tested: installation possible everywhere in Europe

- **SMARTSHELL**
  - s. Manufacturer Meeting
  - Mix of prefabricated modules and gaps covered on site

- **HOLZBAU KAPPLER**
  - S. Renovation Project in Iddstein

- **KOVER FAÇADE SYSTEM** : HTTPS://KOVERSXXI.ES/

CERTIFIED SYSTEMS

1) CONSTRUCTION SYSTEMS:

Passivhaus retrofit system:

- **ECOCOCON Straw Panels:** http://www.ecococon.eu
- **Smartshell reno:** http://www.propassivhausfenster.net
- Prefabfabriek https://prefab-fabriek.nl/
- Viega Nederland https://www.viega.nl/nl/
- Isobouw IsoBouw: Expert en isolation
- Wandshop Prefab HSB Wanden op Maat - Razendsnel Bezorgd - Wandshop
- Kingspan : Panneaux Sandwich Isolants | Kingspan FR
- **Saint Gobain :**

2) TECHNICAL SYSTEMS:

- Heat pumps for retrofit:

- Ventilation for retrofit:

Zehnder : ComfoAir 70

Zehnder : ComfoSpot 50

Glen Dimplex GmbH: DL 50 WH2

BluMartin GmbH : freeAir100

BluMarin GmbH : freeAir100 Premium Cover

Vaventis B.V : fresh-r

Meltem WR GmbH : M-WRG-II E

Meltem WR GmbH : M-WRG-II P

- "Backpackers" (combo systems)

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