# La seconde chance de l'architecture – le bois et les composites bois dans la réhabilitation thermique de l'existant

## Die zweite Chance der Architektur – Holz und Holzwerkstoffe in der energetischen Gebäudesanierung

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# 1. TES EnergyFacade

TES EnergyFaçade[i] is a systemized building method for the assembly of offsite fabricated customized timber façade panels, replacing either certain layers of, or the existing building envelope in its entirety. The basis for the use of prefabricated retrofit building elements is a systematic process of surveying, renovation planning, construction and maintenance of the building stock.

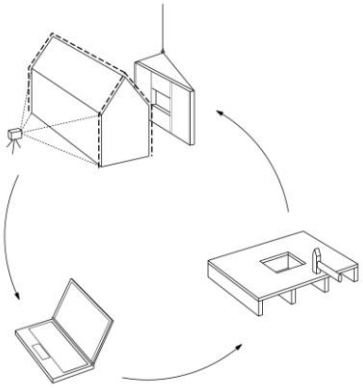
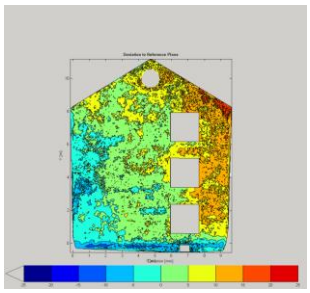


Fig.1 TES method



Modern methods for measuring (i.e. Photogrammetry and 3D laser scanning) generate precise data of the target buildings for 3D-models, which are used for designing prefabricated components for renovating, and finally, for maintenance.
The dataflow matches the requirements of the digital process chain, from site measuring, planning to prefabrication.
TES elements combine a self-supporting structure with insulation infill and paneling, which can be made of a wide range of cladding materials (e.g. timber boards, timber panels, glass, aluminium etc.). High precision building components like windows are easy to integrate due to the modularity.

Retrofitting with customized TES elements can include

- Energy efficient retrofitting of façades and roof
- Renewal or improvement of windows, modification of window openings,
- Extensions, annexes or the addition of spatial elements or balconies
- HVAC modernization
- Integration of solar-active components and / or passive solar heating systems

Fig.2 Workflow

**Central characteristics of the TES method**

a. Construction

- Self-supporting timber frame structure
- Precision and quality of a customized prefabricated building system
- Application of a large variety of cladding materials
- Spatial intervention or modular expansion in a coherent system
- Integration of HVAC and solar-active components
- Integration of load bearing elements

b. Values

- Architectural renewal
- Modification of façade materials and openings
- Improvement to the buildings energy efficiency and increased living comfort
- Ecology - use of timber based materials in façade Elements
- On-site productivity

- Reduced construction time on-site =less noise and disturbance
- Maintenance oriented and end-of-life design utilising LCA methods
- Higher return on investment (ROI) through quality, holistic solutions and industrial productivity
- Product endorsing an ecological lifestyle of health and sustainability (LoHaS)

c. Knowledge
- Systemised workflow
- Digital survey using reverse engineering methods from project start
- Holistic planning process supported by BIM in design, realisation and
- maintenance

## 1.1. Task and potentials

Doubtless, the main task in Europe's construction activities in the future will be the renovation of the existing real estate stock with a strong focus on the ecological improvement of an energy efficient building envelope. The restriction of our energy resources will focus this need drastically. The urge to face up to the consequences of the climate change with the reduction of greenhouse gases (GHG) has been underlined by the publication of the latest assessment report by the IPCC[ii] in 2007.
Buildings are responsible for 40% of energy consumption and 36% of EU CO2 emissions.[iii] Energy efficient building modernization contributes to the reduction of GHG emissions to a significant extent.
Resource efficiency is seen as another key factor in energy efficiency, since the construction sector is responsible for 40 % of EU material flows, as stated by the EU in the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan.[iv]
Two strategies lead to possible solutions. The first relies on the safeguarding and reuse of existing buildings and structures. A second approach promotes a stronger use of renewable resources like timber, timber products and other biogenic building products in construction.

TES EnergyFaçade concentrates on the development of a customized building system using prefabricated timber framed elements including the integration of biogenic insulation materials and techniques, multiple glazing and HVAC components.
"Realizing these savings requires an integrated design process involving architects, engineers, contractors and clients, with full consideration of opportunities for passively reducing building energy demands. Over the whole building stock the largest portion of carbon savings by 2030 is in retrofitting existing buildings and replacing energy-using equipment due to the slow turnover of the stock (high agreement, much evidence).[v]"
Building modernization as a holistic intervention offers a 2nd chance for architecture and urban renewal, including infill development. A great number of buildings in Europe built between 1950-1980 will in any case to be renovated within the next decade due to natural deterioration, technical, architectural and/or social aspects. With regards to this, the improvement of the envelope will offer major benefits to the building's energy consumption saving potential and a vital contribution to the reduction of the global CO2 Stock.[vi]
European wide, there is a particularly high backlog of energy efficient renovations to the insulation layer of the building envelopes, i.e. the exterior wall and roof structures.
The wide spread and most common method is the improvement of the exterior wall through the application of external composite thermal insulation systems based mainly on mineral fibre or polystyrene foam - at the expense of a high outlay of primary energy for production. Their application is weather dependent (temperature above 5°C and dry conditions) and mounting becomes difficult with increasing thickness of the insulation layer.
The common renovation practice can be characterized as follows: craftsman like, non-ergonomic procedures, use of pollutive insulation and construction materials, tailoring and processing on site with high dust and noise emission, substantial off cuts and pollution, disturbance to the neighborhood. The use of prefabricated systems and sustainable raw materials are minor exceptions to the rule.
The exploitation of features of modern digital based survey of buildings, transfer to CAD drawings and the prefabrication of large scale insulated elements is not a common practice.

A TES retrofit is approached as a holistic building modernization including the improvement of a building's self sufficiency in energy production. This approach includes a dramatic reduction of heat and primary energy demand as well as the design and addition of energy productive elements, depending on local conditions. Measures to reduce the heat and primary energy demand in combination with the building envelope include:

- Minimization of thermal transmission losses
- Airtightness Construction
- Ventilation with a high heat recovery ratio
- Windows with low U values
- Integration of shading devices
- Integration of solar active components

The optimization of the building envelope includes improving the insulation for winter and summer, daylight use and the integration of technical features (HVAC, solar panels). A core task of energy efficient building design is to reach the required indoor environmental quality with a minimum of primary energy demand and a simple energy supply system.[vii]

## 1.2. Improvement of Energy Efficiency / Energy efficiency as an architectural aspect

Town planning measures have been developed to increase the density of existing urban structures which can be achieved by adding roof floors, neighborhood specific infill developments or extension of building spaces. In addition, the TES method for improving the energy efficiency of the building envelope completes the scope of 'Additions & Alterations'. Modern timber construction offers a consistent compatible building system and a wide range of spatial and technical solutions, which can be applied to the different tasks. The architectural appearance of both buildings and built environment can be substantially improved by restructuring façades, exchanging façade materials, adding extensions, annexes or additional stories. The geometry of the building may be modified by adjusting openings and integrating loggias or balconies to the heated living area. Aside from that, the existing built environment contains a cultural heritage which should be preserved for future generations. A retrofit method which can be affixed to the existing substance and that is possible to dismantle thanks to its modular concept offers new perspectives for cultural preservation. Annexes or extensions can be added to the building increasing the productive floor area.

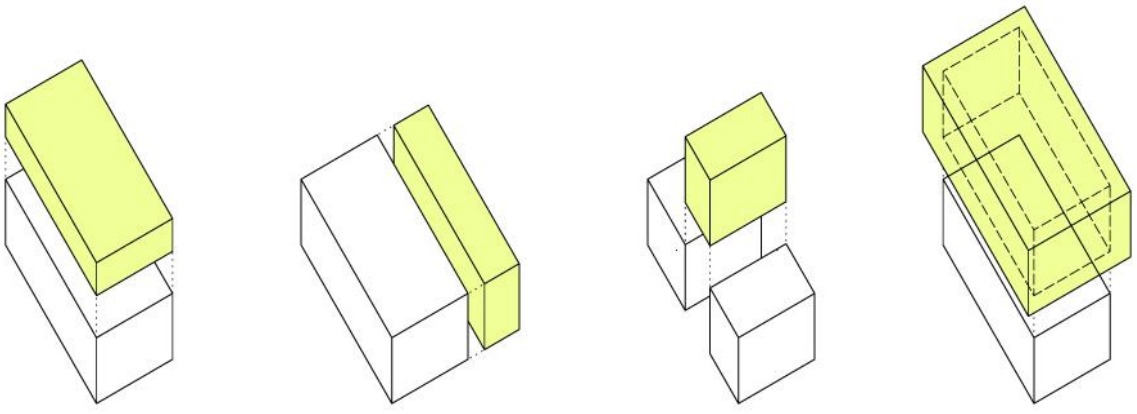


Fig.3 Infill development with TES:
1. Additional storey
2. Annex
3. Infill
4. Replacement of / addition of envelope

Updating the building stock often require retrofitting strategies that not only improve the technical performance of a building but also adjust space and appearance and thus the architecture. These include the integration of technical systems, solar design and extensions or changes to the existing floor plan structure.

Use, function, technical services and appearance of the building stock often no longer meet today's demands and expectations of modern architecture. Social and cultural ways of living and housing have changed - brought about by developments in family structures, work-life balance and aging societies etc. - and demanded adapted solutions. The appearance and functional properties of the building stock are the results of the visions and inventions of their time and their renewal needs comprise aspects. In many cases the building structure can be modified and extended and retrofitting becomes a smart alternative to total demolition and rebuilding. Schwanenstadt's school and the student apartments Neue Burse Wuppertal provide compelling examples.[viii]

# 2. Systemised workflow

The TES method is a systemized modernisation process from survey, planning, production off-site to assembly on-site as a consistent structure along a digital based workflow. It provides the essential data and allows the integration from first sketch to the mounted façade. Planning, energy simulation and production design, based on BIM data, supports the control of the energetic performance and economic optimisation. Furthermore the holistic method allows the integration of multiple functions in one building system, due to the openness of TES method, one of its core concepts. Necessary responsibilities of all participants are set within the frictionless digital workflow as state of the art in survey, planning and production.

**digital measurement – planning off-site fabrication – on-site assembly**

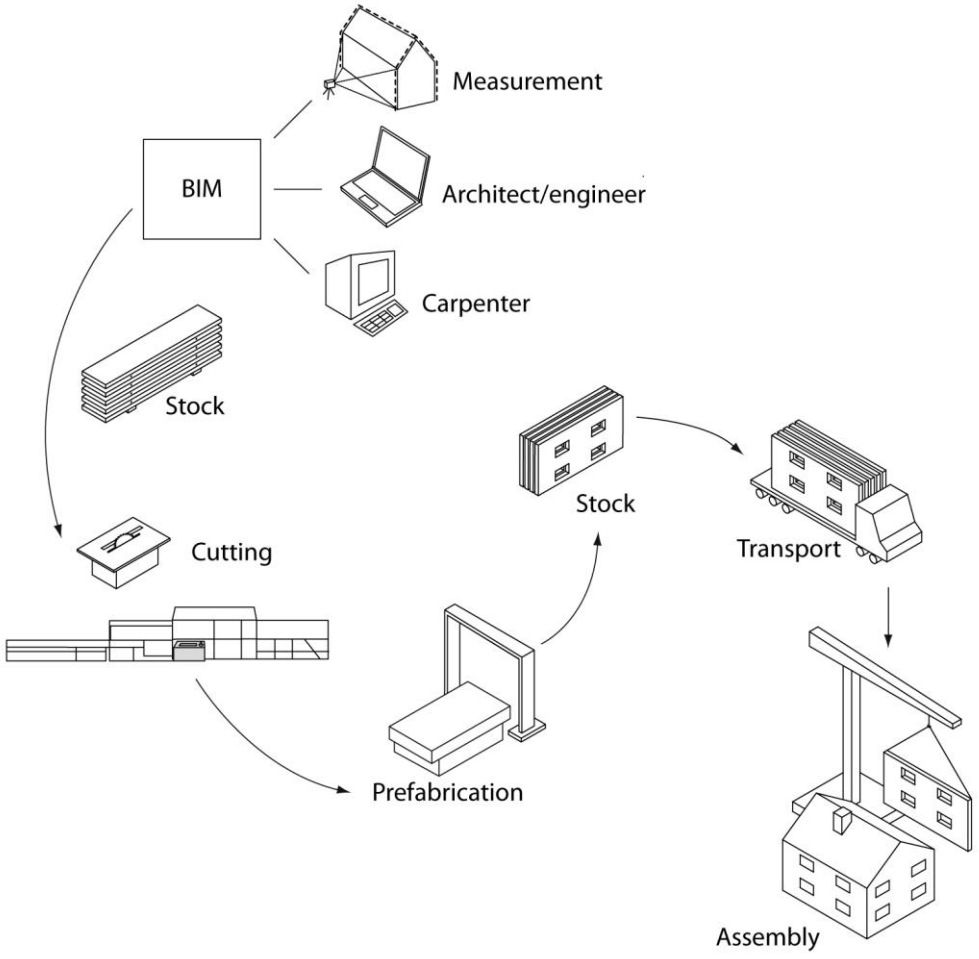



Fig.4 Digital workflow

Prefabrication demands detailed information on the renovation object. On the basis of an accurately measured building survey, customised TES elements are fabricated off-site according to the project specific design at the factory. These can include ready-assembled cladding, integrated window modules and, if necessary, interior surfaces.

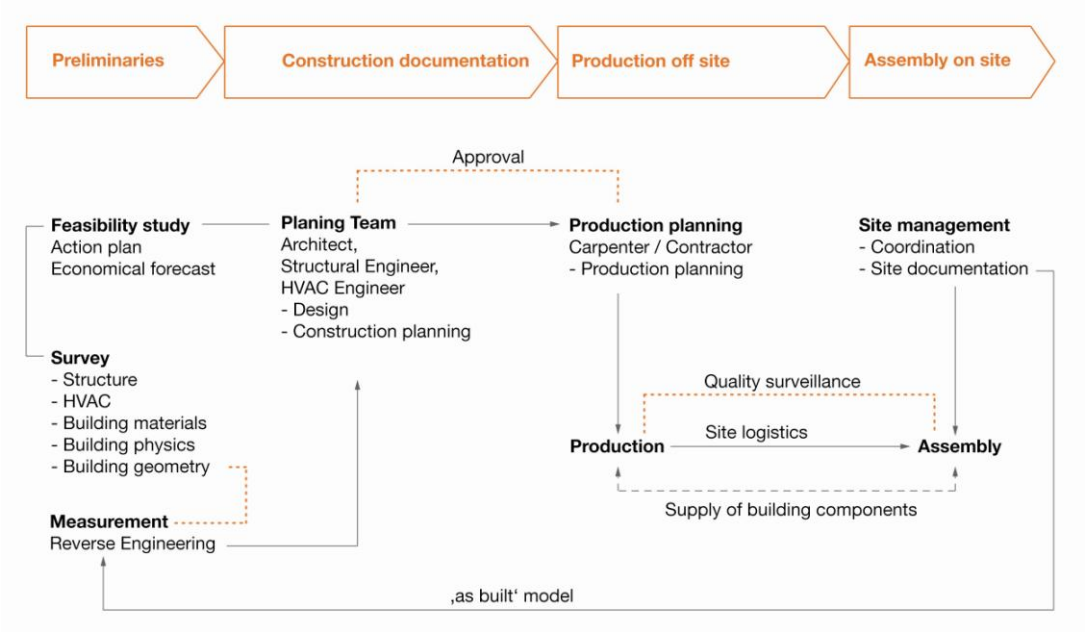



Fig.5 Process from planning to production

A shorter assembly process on-site and fewer restrictions due to construction work compared to conventional renovation methods is an exceptionally valuable quality for owner-occupied flats or buildings under operation.

**Prefabrication**
In the timber construction sector, advanced methods of prefabrication[ix] are verysuccessfully used in a contemporary fashion to produce and sell new energy efficient buildings, and are consistently gaining market share. Prefabrication allows the integration of building components such as windows, building services systems and ready-made surfaces of the façade elements in the controlled and ergonomic working environment of the factory. A flexible workflow from design to production allows for customised fabrication of single building parts, taking into account the specific needs of individual buildings, e.g. size, unevenness etc.

**Digital Surveying - Reverse Engineering**
Combining the conditions of an existing object with new adapted and industrially manufactured parts leads to the paradigm of reverse engineering (RE). RE is described as the concept of planning and production of parts based on a digital model derived from digital imaging results which are taken from a physical object. Survey methods applied are photogrammetry, tachymetry and/or 3D laser scanning.

**Digital Workflow**
Planning methods are based on CAD/CAM models for production, integrating the results of RE. The high accuracy and the control over data integrity is backed-up by a digital workflow. Building information modelling as a tool integrates all information and supports the planning, construction and maintenance process. Lastly the digital workflow ensures the stencil like fit of the new TES elements onto the existing façade.

**On-site Productivity**
The builder will be able to achieve higher work productivity for the whole process and especially the mounting phase. Supply processes for elements can be optimized in the workshop, e.g. material flow and efficiency, machine employment, etc.. The work load on-site is minimized to the handling of just-in-time provided parts. This avoids organisational work, unproductive time, preparation work and enhances the productivity on-site substantially.

**Architectural Renewal**
The use, function, technical services and appearance of the building stock often no longer meet todays demands and expectations of modern architecture. Building modernisation becomes the 2nd chance for architecture, improving the technical performance of a build-

ing, adjusting space and appearance. TES EnergyFaçade includes the integration of technical systems, solar design and solutions for extensions or changes to the existing layout. The timber frame structure provides a certain load bearing capacity, allowing the application of different surface and cladding materials.

# 3. Experiences made

Experiences were made in demonstration projects during the planning and construction process. The projects are undergoing monitoring in order to learn about the effects, behaviour and condition of the construction after a modernisation with TES elements. Most important experiences at this stage:

## 3.1. Survey

The measuring methods are based on remote sensing technologies applied by surveyors who delivered precise data of the existing building. The most important tasks are the predefinition of all points to be measured and a common interpretation of the results in a team of surveyors, planners and carpenters.

## 3.2. Planning

The issue of fire safety of the whole building has to be considered seriously at the very beginning of the planning stage. The validity of today's building regulations has to be checked carefully and measures (e.g. additional fire doors, stairs etc.) have to be realized.

## 3.3. On-site mounting

The situation of the site (access, space etc.) determines the logistics of transportation and mounting. The level of prefabrication depends on the geometry of the buildings. The seize and the weight of elements with insulation, windows and glazing has to be considered, as the possibility of crane positions and lifting processes on-site are a determining factor.

**Risør technical College, Norway 2009**

| | |
|---|---|
| Owner | Aust-Agder county |
| Location | Risør, Norway |
| Architect | Arkitektstudio AS |
| Contractor | Trebyggeriet AS |
| Construction | mid 1960´s |
| Modernisation | 2009 |
| Storeys | 2 |

Heat Energy demand
kWh/m²a (before/after) 325,0/ 49,0

Fig.6 Risør College, new façade 2009

**Realschule Buchloe, Germany 2009**

| | |
|---|---|
| Owner | Landkreis Ostallgäu |
| Location | Buchloe, Germany |
| Architect | e3 architekten |
| Contractor | Josef Ambros GmbH |
| Construction | 1980 |
| Modernisation | 2009 |
| Floor area net | 8.903 m² |
| Volume | 27.822 m³ |
| Surface | 5.688 m² |
| Storeys | 3 |

Energy demand kWh/m²a (before/after)
Primary energy demand 125,0 /17,0
Heat energy demand 89,9 / 16,0

Fig.7 Realschule Buchloe, 2009

The school building is a concrete skeleton structure with a non-load bearing façade that was replaced by prefabricated TES elements.

Fig.8 Realschule Buchloe, removal of precast concrete façade

The work was done during school holidays in 2009 to minimise the disturbance for the user. Metalworkers and carpenters where working hand in hand to remove
the existing steel façade and mount the TES elements at the same time.

Fig.9 Realschule Buchloe, Mounting

# 4. CONCLUSIONS

Retrofitting with prefabricated elements offers the second chance for architecture! The concept (as well as the projects) shows a wide range of varieties of the sustainable and durable timber construction system.
The TES method provides the basis for the further development of a prefabricated timber building system for the energy efficient building modernization based on the experience and competence of the timber construction sector. Retrofitting systems with value-adding attributes (i.e. elements with integrated components) and customized process solutions from design to production will provide the answer to a new, industrialised holistic and cost-efficient retrofit system.
The properties of TES are convincing:

- Precision and quality of an ecological building system
- Predictable pricing and reduction of work on-site
- Reduction of noise and disruption of the inhabitants
- Application of a great variety of cladding materials
- Integration of load bearing elements
- Integration of HVAC and solar-active components

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[i] TES EnergyFaçade was funded in the ERA-NET "WoodWisdom-Net. German funding was provided by German Federal Government, Federal Ministry of Education and Research, BMBF. Partners of TU München (project coordinator) in
TES EnergyFaçade research project were: NTNU Trondheim, Norway; Aalto University Helsinki, Finland and SME of all three countries. Support on the building survey by the Chair of Geodesy, Prof. Wunderlich, TU München, Germany.

[ii] IPCC, Forth Assessment Report, 2007

[iii] http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm (28.05.2010)

[iv] COM(2008) 397 final, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008DC0397:EN:NOT, verified 06.11.2009.

[v] http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch6s6-es.html, last access 10.08.10, 14:00

[vi] Energetische Gebäudesanierung mit Faktor 10, Dr. Burkhard Schulze Darup, DBU, 2004

[vii] Hegger, Fuchs, Stark, Zeumer; Energie Atlas, Institut für internationale Architektur-Dokumentation, München, 2007

[viii] Schule Schwanenstadt, Austria; PAUAT Architekten; 2004; Neue Burse, Germany; Architektur Contor Müller Schlüter, 2003

[ix] Kolb, Josef; Holzbau mit System, Birkhäuser 2007