TES EnergyFacade

FINAL REPORT

Title of the research project	**TES EnergyFacade**
Coordinator of the project	Dipl. Ing. Frank Lattke

BASIC PROJECT DATA

Project period	01.01.2008 – 31.12.2009
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URL of the project	http://www.tesenergyfacade.com

FUNDING

Total budget in EUR	848.744 EUR
Public funding from WoodWisdom-Net Research Programme:	Total funding granted in EUR by source:
Finland Tekes - Finnish Funding Agency for Technology and Innovation	145.000 EUR
Germany Federal Ministry of Education and Research (BMBF)/ Project Management Agency Jülich (PtJ)	296.244 EUR
Norway The Research Council of Norway (RCN)	212.500 EUR
Other funding:	
Industry funding, Finland	45.000 EUR

PROJECT TEAM (main participants)

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ABSTRACT

The improvement of the energy efficiency of the envelope of buildings built from 1950-1980 is a major benefit to the energy saving potential as well as a vital contribution to the reduction of the household's total CO2 emissions.
The goal of the project was to develop a façade renovation method (TES method) based on large scale, timber based elements for the substantial improvement of the energy efficiency of a renovated building, which would be applicable throughout Europe.
The target of the TES method is primarily focused on the building's energy efficiency improvement and as a consequence in the reduction of GHG emissions. Every activity in construction is responsible for the consumption of additional resources in the form of raw materials or energy and therefore causes emissions. A possible solution to this dilemma is the adoption of a sustainable and ecological retrofit method based preferably on biogenic materials. The timber based value chain offers an enormous potential to activate the carbon stock as timber is the only regrown building material. Along the value chain of timber, combustion of wood has to stand last.

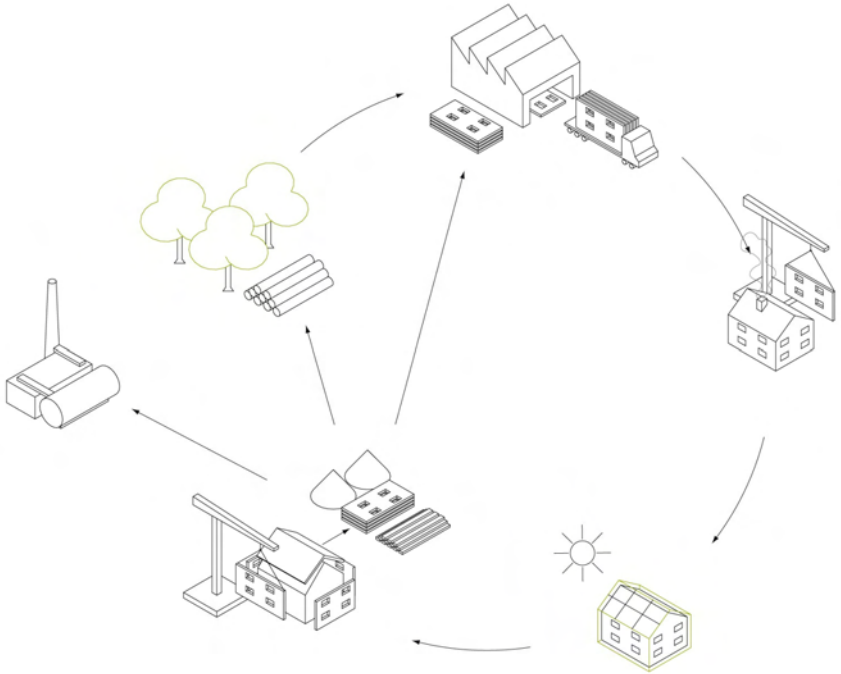

Fig. 1 – Timber based value chain – building modernisation offers new chances

TES EnergyFacade has defined basic principles for the energetic modernisation of the building envelope using prefabricated large-sized timber frame elements. The basis for the use of prefabricated retrofit building elements is a frictionless digital workflow from survey, planning, off site production and mounting on site based on a precise initial 3D measurement.

The outstanding properties of the application of TES EnergyFacade are:
• 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
• Spatial intervention or expansion (modules) in the same system

1.1 Introduction

1.1.1 Background

A great number of buildings in Europe built from 1950-1980 has to be renovated within the next decade. Regarding this situation, the improvement of the building envelope will be a major benefit to the energy saving potentials of a building and a vital contribution to the reduction of the household's total CO_2 emissions.

Heating energy demand and greenhouse gas emissions can effectively be reduced by thermal enhancement of the building envelope, i.e. improvement of airtightness and the reduction of heat transmission through the building skin. Outer walls count for up to 80 - 90% of assembly related heat energy saving potential, windows for around 50%.[1] This offers a great market potential for timber and timber products, if the TES method succeeds to supply appropriate timber building systems with a strong focus on the ecological improvement of an energy efficient building envelope.

TES EnergyFaçade is a systemised building method for the assembly of offsite fabricated customised 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.

1.1.2 Objectives

- Definition of the requirements and the standards for the design of large-scale prefabricated elements based on timber and other biogenic based construction materials for the improvement of the energy efficiency of the building envelope (TES-EnergyFacade) of the existing real estate stock and thereby create the basis for the development of an European wide marketable construction system
- Development a prototype design of a wood-based prefabricated façade element system
- Optimisation of a frictionless 'digital chain' of the whole process (i.e. on site measurement-planning-production-mounting) to improve the workflow
- The project results will be evaluated in prototypes and published in a TESmanual

1.2 Results and discussion

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, production and assembly.

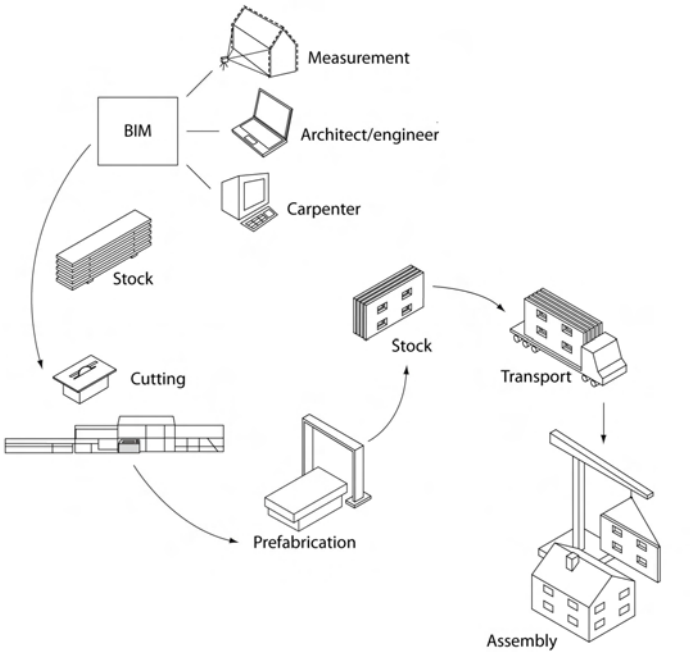

Fig. 2 – Off-site fabrication based on frictionless digital workflow

[1] Institut Wohnen und Umwelt (IWU) (ed.) 2006: Gebäudetypologie Bayern, Darmstadt, S.15ff.

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.
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.

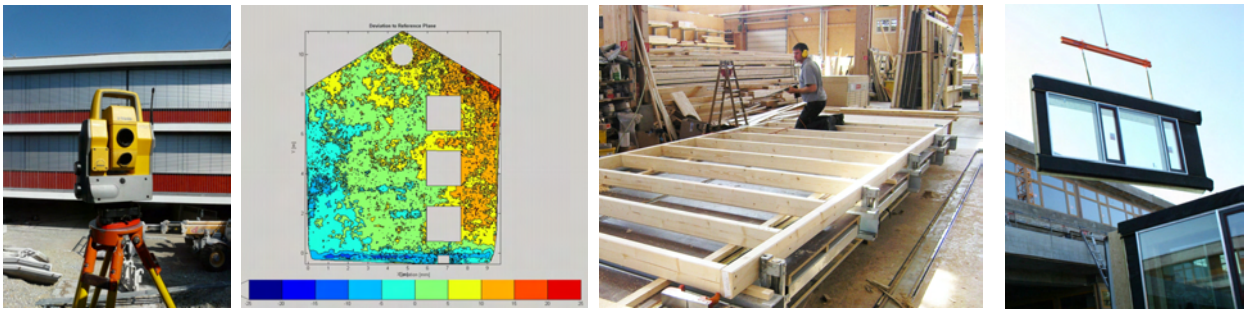

Fig.3 – From Survey to Assembly

Characteristics of the TES method

Construction	• Self-supporting timber frame structure • Precision and quality of a customised 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
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)
Knowledge	• Systemised workflow • Digital survey using reverse engineering methods from project start • Holistic planning process supported by BIM in design, realisation and maintenance

Experiences were made in demonstration projects[2] 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:

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.

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. 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.

1.3 Conclusions

Retrofitting with prefabricated elements offers the second chance for architecture! The concept of TES EnergyFacade as well as first pilot projects offers 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 modernisation based on the experience and competence of the timber construction sector. 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. Retrofitting systems with value adding attributes (i.e. elements with integrated components) and customised 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

[2] Risor Technical College, Norway; Realschule Buchloe, Germany

1.4a Capabilities generated by the project

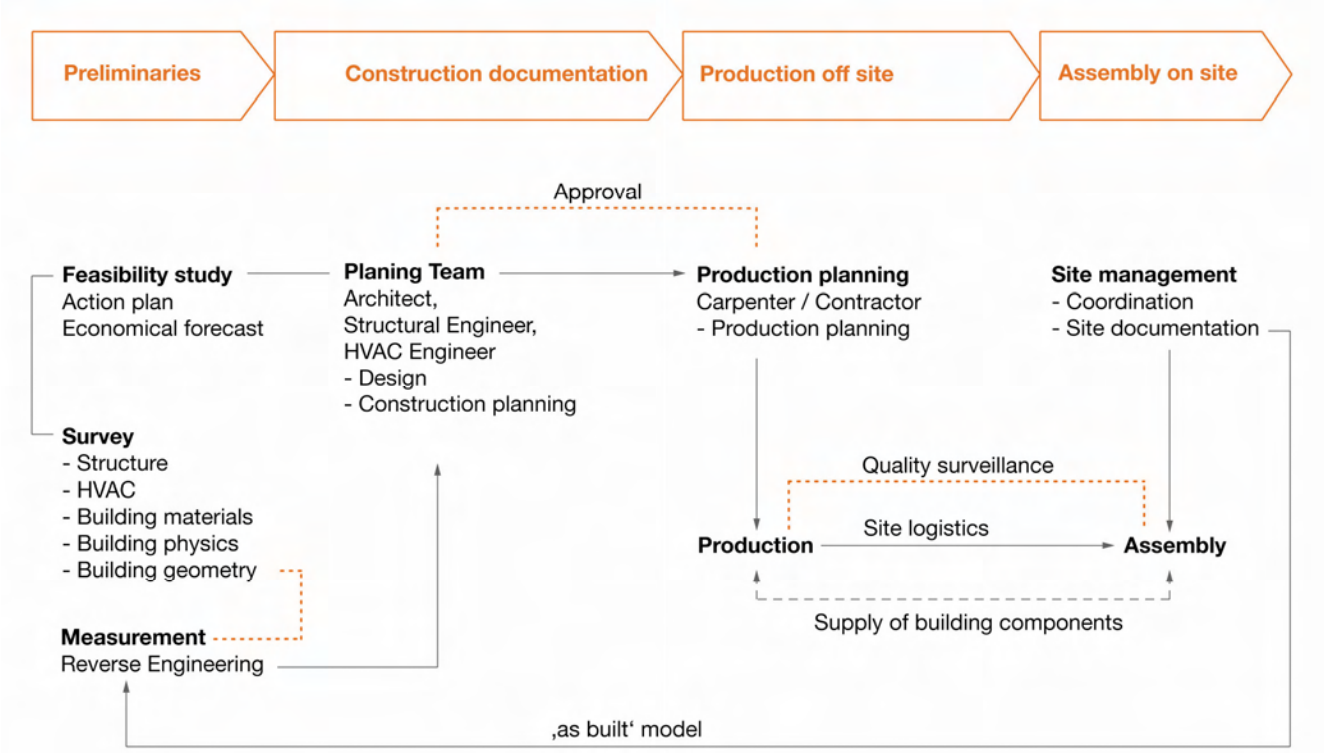

Fig. 4 – Planning and production process

Along the process chain of building modernisation with off-site fabricated timber building elements the most important questions have been answered:
- Survey and measurement in high precision is state of the art
- Definition of basic TES elements
- Solution for basic joints and connections to existing building structures

The project has revealed potential business opportunities especially for the phase of the feasibility study where the first customer relation is built up. Whereas other building material sectors provide complete information services, the timber construction sector lacks of a wide spread marketing strategy. In order to exploit the huge market potential of building modernisation, the task will be to develop marketing strategies to convince future customers at the very beginning of the decision making process.

The TES method itself targets a timber construction sector that is only partially prepared for the upcoming market potential as we have learned about the differences in competences of production and working methods throughout Europe. This offers a development potential for small and medium entrepreneurs as well as larger industries.

The research project has evoked several tasks which need to be answered, e.g. the optimisation of production and building processes, envelope solutions integrating building services, light weight constructions. The participants will continue their effort with smartTES, a project that was approved in the 2nd call of WoodWisdom-Net in late 2010.

1.4b Utilization of results

TESmanual
The results of the project are summarized in a TES manual to provide experts (real estate companies, planners, public clients, contractors etc.) as well as the timber construction sector with the necessary know how. The process of modernization with prefabricated timber elements will by systematically presented and guidelines offered to manage key issues in planning, fabrication and assembly.

Public relations
The project is presented on several national and international symposiums (e.g. EBH Köln D, Energy transition at housing renovation Roosendaal NL, Finnbuild messut, Helsinki FI etc.) and has been widely published in specific media (e.g. zuschnitt AT, mikado D etc.)
In workshops we address the potential of the project to public and private home owners. Our team is supporting clients and planners in the first step of a modernization project with technical background information and feasibility studies (e.g. Zentrum für elementiertes Bauen Bühl D).
Through the attention raised, our enterprise partners were able to build up international contacts and new business relations (e.g. Netherlands / Alexander Gumpp D) and achieve contracts in publicly tendered projects (e.g. Trebyeggeriet/Risør College NOR, Ambros Holzbau/RS Buchloe D).

Pilot projects serve as a hands-on field study and best-practice examples for the implementation of the research results. We have provided our knowledge and experience to the planners and companies involved.

Risør Technical College

Fig.5 - Risør Technical College

Location / Client	Risør, Norway / Aust-Agder provincial government administration
Status	Completed in 7/2009
Architect / Builder	Arkitektstudio AS / Trebyggeriet AS
Form of collaboration	Joint project workshop of the R&D team in a planning phase. The timber contractor (partner in the R&D team) profited from sharing knowledge and experience with the other entrepreneurs involved. Monitoring and evaluation through NTNU, Trondheim
Innovation / experience made	First of its kind retrofitting project in Norway with a constant workflow from survey to fabrication and assembly. Cladding treatment with a innovative mineral paint (Keimfarben), characterized by a longlife maintenance interval of at least ten years.

Realschule Buchloe

Fig. 6 - Realschule Buchloe

Location / Client	Buchloe Germany / County of Ostallgäu
Status	Completed in 9/2009
Architect / Builder	e3 architekten, Marktoberdorf / Ambros GmbH Hopferau
Form of collaboration	Planning workshop with architects, timber contractor and research to find solutions for fire safety and fixation of the elements to the structure. Optimization and monitoring of the workflow.
Innovation / experience made	Passive house standard, use of large scale elements. Structured workflow from survey-planning-dismantling of the old building envelope assembly of the new timber framed elements

1.5 Publications and communication

a) Scientific publications

1. Articles in international scientific journals with peer review

Lattke F (2009). Eine zweite Chance für die Architektur – Holz und Holzwerkstoffe in der energetischen Gebäudemodernisierung zuschnitt 34, proHolz Austria*

Larsen KE, Lattke F, Ott S, Winter S (print 2011) Surveying and digital workflow in energy performance retrofit projects using prefabricated elements, Automation in Construction*

2. Articles in international scientific compilation works and international scientific conference proceedings with peer review

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Ott S, Winter S (2010) TES EnergyFacade – Sustainability and Environmental Impact, WCTE 2010, World Conference on Timber Engineering*

Ott S, Winter S (2010) TES EnergyFacade – Construction principles, WCTE 2010, World Conference on Timber Engineering

3. Articles in national scientific journals with peer review

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4. Articles in national scientific compilation works and national scientific conference proceedings with peer review

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5. Scientific monographs

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6. Other scientific publications, such as articles in scientific non-refereed journals and publications in university and institute series

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LECTURES/SEMINARS/WORKSHOPS:

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Lehto J, Presentation of drafts for the TES pilot, FI-Oulu 23.09.2008
- TES and SQUARE research teams

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Energiatehokkaiden rakennusten suunnittelu
- Public domain, architects, timber industry

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- Journalists

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- Experts

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- Architects, carpenters, timber industry

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- Architects, carpenters, timber industry

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- Seminar for Architects and carpenters

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- Architects, carpenters, timber industry

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- Carpenters

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- Architects, engineers

Lattke F, TES EnergyFacade - a timber building system for the modernisation of social housing , International symposium “Energy transition at housing renovation, a successful approach”, 13.10.2009, NL-Roosendaal
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- Politicians, forest and timber sector

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- Carpenters

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- Researchers, FTP members

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- Researchers, FTP members

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- Carpenters

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- Architects, carpenters, home owners

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- Architects, carpenters, home owners

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1.6 National and international cooperation

Our research team combines the experience from scientists and fabricators of timber framed elements from the timber construction sector in 3 nations (Finland, Germany and Norway), working in close collaboration and driven by the common objective of bringing the experiences of the timber building sector and prefabrication methods into the field of renovation: thus exploring new markets and contributing to the challenge of reducing the global CO2 footprint. The intensive exchange between research and entrepreneurs stimulated the whole process in this project.

STAGE 1: Investigation and statement of requirements
Learning from built projects. A general survey of the typology of the existing real estate stock on a national level with a focus on the suitability for the renovation with prefabricated elements was followed by the definition of the most important and numerically relevant types. This led to drawing up of the specific demands for the renovation of the building envelope were developed.

STAGE 2: Systemisation of requirements
The results were compiled, compared and discussed at an early stage. The objective being the definition of a concerted statement of requirement regarding national specifics. Within a broad variety of possibilities a number of solutions were identified from a broad variety of possibilities through critical analysis, and were then jointly perfected.

STAGE 3: Design / implementation and project documentation
The national partners developed prototypes according to their specific work package that were tested and evaluated on suitable pilot projects in the partners' countries. The results were jointly analysed.

The partnership has provided partners with insight to each other's researching methods and traditions. The cooperation has advanced during the project. Project meetings held at a regular basis have been relevant for the dissemination of knowledge, research results and the development of the project. Contacts to other countries industrial partners have been fruitful, even exchange on an internship basis were realised.

The contact between the partners on a national basis is very close – especially the SME partners were well involved in the project. The exchange between the academics and the practitioners was a huge benefit to all participants with effects on our daily work as the contacts are advancing in other projects.
Cooperation and networking with non-partners
The contacts to other research projects started in 2008 were deepened throughout the project (e.g. Annex 50, SQUARE, WEFAM etc.). Especially on side venues of international conferences (ÖKOSAN, Austria; Holz Bau Energie, Köln etc.) or in direct contact to other institutions (EMPA Zürich etc.) exchange of experience was made as well as joint actions planned and taken.
The FTP conference in Stockholm was a valuable occasion to present the project outcome and find expressions of interest.

In Finland cooperation was executed with the international SQUARE project, sharing the same object as pilot as the Finnish TES research team. The pilot is a student housing apartment building situated in Pohjankaleva, Oulu. http://www.iee-square.eu/.

Contacts were made to HBZ Schleswig-Holstein, which opened the chance to present our experience to architects and builders in north Germany. The HBZ is following several school modernisations and has strongly emphasized the TES method for at least four large scale projects.

From research to business - demonstration projects
Experiences were made in demonstration projects in Risør, Norway and Buchloe, Germany 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.

The group was able to build up contacts to planning teams of several modernisation projects especially in Germany (e.g. GWG München, WBG Augsburg, School Sonthofen, School Gundelfingen). These projects will be documented as best practice examples offering the possibility to further widen our experience and to demonstrate the practicability and acceptance of the TES method.

Investigation led to cooperation with a client and architects who are refurbishing a large school building in Buchloe. The team participated in the process as a consultant to the architects who were planning a prefabricated solution. The monitoring of the project in 2010/2011 was made possible with a small grant from Deutsche Bundesstiftung Umwelt DBU.
Josef Ambros was able to contract the refurbishment job of the school in a public tender and thus providing the whole team with insights to the building process and site experience.

In 2009, the first FTP Team Up Award, a prize in recognition of outstanding science-business collaboration in the forest-based sector, was awarded in Stockholm to the team of TES EnergyFacade.

In 2010 two future research projects (smartTES and E2ReBuild) were granted to the applicants. The core team of TES EnergyFacade participates in larger consortia and has the possibility to further develop the method of building modernisation with prefabricated building elements and thus advancing the timber construction sector.