RENEW SCHOOL

Sustainable school building renovation promoting timber prefabrication, indoor environment quality and active use of renewables

http://www.renew-school.eu

Report

April 2017

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Content

Introduction

All over Europe both energy and education related developments require adaptations of our school buildings. Most of them have been built during the 1960s, 1970s and 1980s, they are now expected to be modernised and renovated. Comprehensive school (building) renovation concerns the whole system and meets the technical and educational needs of the future. The central point from the technical point of view is the optimized operation of the building services, a high quality of building construction and a surplus value for the user's indoor comfort. This surplus can only be achieved, when new methods and technologies are developed further.

The project "RENEW SCHOOL" aimed at promoting and increasing high-energy performance and prefabricated timber-based renovation of school buildings in Europe, addressing high indoor environmental quality and high share of renewable energy sources. All publications such as school's technical and financial signpost and frontrunner folders are available at: www.renew-school.eu!

The Consortium:

AEE INTEC	Coordinator AEE - Institute for Sustainable Technologies (AEE INTEC), Austria
pixii	Pixii - Kennisplatform Energieneutraal Bouwen, former Passiefhuis-Platform vzw (PHP) Belgium
holzcluster steiermark gmbh	Holzcluster Steiermark GmbH, Austria
habitech IL DISTRETTO ENERGIA AMBIENTE	DTTN – Trentino Technological Cluster, Italy
Lesarski grozd Wood Industry Cluster	Wood Industry Cluster, Slovenia
DTU	DTU Technical University of Denmark, Civil Engineering - Building Physics and Services (DTU – BPS), and International Center for Indoor Environment and Energy (DTU – ICIEE), Denmark
asplan viak	Asplan Viak AS, Norway
NAPE NARODOWA AGENCJA POSZANOWANIA ENERGII S.A.	Narodowa Agencja Poszanowania Energii S.A., Poland
CHALMERS	Chalmers tekniska högskola, Sweden

Fraunhofer IBP	Fraunhofer-Institut für Bauphysik IBP, Germany
INFORMEST	Informest - Centro Di Servizi E Documentazione Per La Cooperazione EC, Italy
	AG Stedelijk Onderwijs Antwerpen, Belgium
eERG end-use Efficiency Research Group Gruppo di ricerca sull'efficienza negli usi finali dell'energia; POLITECNICO MILANO	Politecnico di Milano, Dipartimento di Energia, Italy

Consortium member countries of RENEW SCHOOL

1 Executive Summary

School buildings are places of major public interest. Our children are educated in life's basics, in some schools beyond that. Therefore not only the educational system itself, but also the conditions of these buildings are very important signals to the public, even to the pupils themselves.

The RENEW SCHOOL supported and promoted, and so initiated high-energy performance and highly replicable school building renovations. These renovations are carried out by coating the buildings with multipliable, prefabricated and insulated timber modules, integrating ventilation, passive cooling like night (free) ventilation, intelligent shading and renewable energy sources. This "RENEW SCHOOL way" of renovation is applicable to many public buildings turning to NZEB which are in need of short renovation time or staying in operation for clients during renovation works.

The RENEW SCHOOL project promoted measures to downsize the energy use significantly, creating comfortable conditions for the pupils and teachers in schools. Sustainable school renovation actions build on:

- Improvement of the building's envelope by coating it with insulated prefabricated timber elements
- Improvement of the indoor environment quality (IEQ) by ventilating, passive cooling and daylight
- Improvement of the energy gains on site by using active renewable energy sources, beside the passive ones, integrated in the school buildings

These focus points have been transferred to the European market by the 13 consortium members. The RENEW SCHOOL project has so:

- Assisted the target groups in their wish of affordable, economically, user friendly, energy efficient and sustainable school renovation concepts by offering cooperation and technological signpost and tools
- Forced the know-how exchange of multipliable renovation methods managing energy savings and integration of renewable energy in educational buildings by various visits and networking events
- Provided and convinced the users by awareness projects and small and middle sized enterprises (SME) by trainings of the need for advanced renovation methods

The main activities and achieved results of RENEW SCHOOL have been the following:

- 27 visits to the 19 visualised frontrunner and other nZEB school buildings with 970 participants of the target group - the school financiers, owners, users and planners
- 20 school buildings renovations to nZEB standard, initiated by the project, partly in the "RENEW SCHOOL way"
- Creation of a web-decision "Renewschool"-tool as a guide to well-informed decisions for school buildings and renovation options: http://schoolrenovatie.be/en/homepage/
- 20 technical workshops on cooperation models and on technological options for nZEB school renovations have been held together with 8 technology talks to bring financiers and companies together
- Around 3.180 pupils assisted by their teachers have carried out and participated in awareness raising school projects on nZEB renovation and environmental topics
- 50 training courses and webinars for 1.458 employees of 632 SME on specific technologies and constructions in comprehensive school renovation have been carried out
- An active website www.renew-school.eu serving as contact and information exchange platform for the stakeholders and network activities with around 1.600 visits per month in average
- 10.500 interested persons of the target group have been reached personally either provided with brochures, the RENEW SCHOOL video, presentations or took part in a RENEW SCHOOL event

2 Project Approach and methodology - Aim & Objectives

All over Europe energy and education related developments require adaptations of our school buildings. Most of them have been built during the 1950s to 1980s, they are now expected to be modernised and renovated.

The project aimed at raising both the number of high performance school buildings retrofit and the uptake of the market for prefabricated renovation solutions using insulated timber modules as sustainable method. This renovation concept must go hand in hand with creating high indoor air quality and comfort for the pupils which are nowadays often lacking these healthy school conditions. Doing so, ventilation and heating pipes, ventilation units, thermal optimised windows and shading devices can be integrated in the modules and mounted in quick time onto the façade. Theoretically the renovation can be carried out during the school season without great disturbance because it takes only one week to insulate about 3.000 m² façade area and most of the installations are accessed from the outside wall (see Figure 1), less work inside.

Figure 1 Integrated wooden frame windows and solar shading in a big prefabricated timber module for renovation of a school façade (Source: PAUAT Architekten)

So the project laid the foundation for sustainable educational buildings promoting energy efficiency with high indoor environmental quality and excellent conditions for new education. RENEW SCHOOL tried to bring together European representatives of the target groups to promote nZEB school building renovation like it should be: Quickly done. Carried out in high quality. Considering the users by implementing solutions like suitable ventilation and passive cooling. Integrating renewable energy sources as important signal to the public.

The main and most important target groups of RENEW SCHOOL were:

- The **school owners** and **financing bodies** of the school buildings (**financiers**) like municipalities, local, regional and national governments or outsourced real estate companies managing them
- The **companies and SME** of timber manufacturers and craftsmen, ventilation, solar shading and renewable energy branches which should offer and carry out high quality renovation works

The second relevant target groups of RENEW SCHOOL were:

- The planners, architects and building professionals who should know how to design and use the technologies needed for high quality (school) renovations in “RENEW SCHOOL way”
- The school users like pupils, teachers, caretakers and heads of schools who should know and profit from the renovation measures carried out by the above mentioned target groups

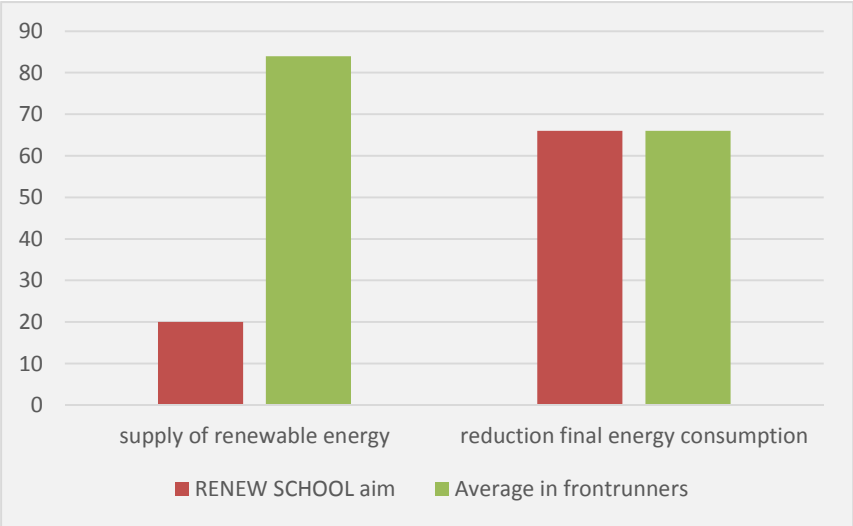
Different activities were set to attract these target groups and push them towards sustainable school building technologies for renovation, but also applicable for new built: Surveys were carried out among school owners, company representatives, care takers and users for the “The owners’ and industries’ needs report”, but also among the contractors and planners of the frontrunner schools, and among pupils and teachers related to indoor environment conditions. Workshops with technical topics on financing, cooperation models and of course technical solutions were held to discuss good examples and new developments. Technology talks, frontrunner visits and dissemination events were organized to bring school financiers, SME, the industry and users together discussing new renovation concepts. For educational and information reasons school projects and trainings for SME have been implemented. The project website should support these activities with helpful information.

3 Activities and events

All in all 122 events which have been directly organized by the RENEW SCHOOL project partners have attracted 7.500 persons of the target groups in 9 different countries. RENEW SCHOOL, in line with different previous projects, has shown that frontrunner visits, training activities on specific professional issues and networking events are of mayor importance to establish contacts leading to further activities such as comprehensive school building renovations.

3.1 Frontrunner Visits

19 frontrunner buildings were collected from the 9 partner countries. Information folders were produced, displaying information on financing, construction method, energy data/supply, ventilation and indoor air quality as well as some lessons learned. The renovated school buildings should have reduced their final energy consumption down to one third of the original value, in addition reach a renewable energy share of min. 20% after renovation. These targets were successfully met by the frontrunners as can be seen in Figure 2 below.



The percentage of renewables in the frontrunners vary from 0-100% - the average being 84 % (Project aim: 20 %)

The average reduction of the final energy consumption for the renovated frontrunners is 66 % (Project aim: 66 %).

Figure 2 The share of final energy reduction and supply of renewable energy by the RENEW SCHOOL frontrunner buildings

Professional folders were elaborated to display these good example buildings at our project website and 100 copies of each frontrunner in English were printed to distribute them at project events like workshops and visits. Figure 3 depicts how the frontrunner folders were visualized for the target groups.

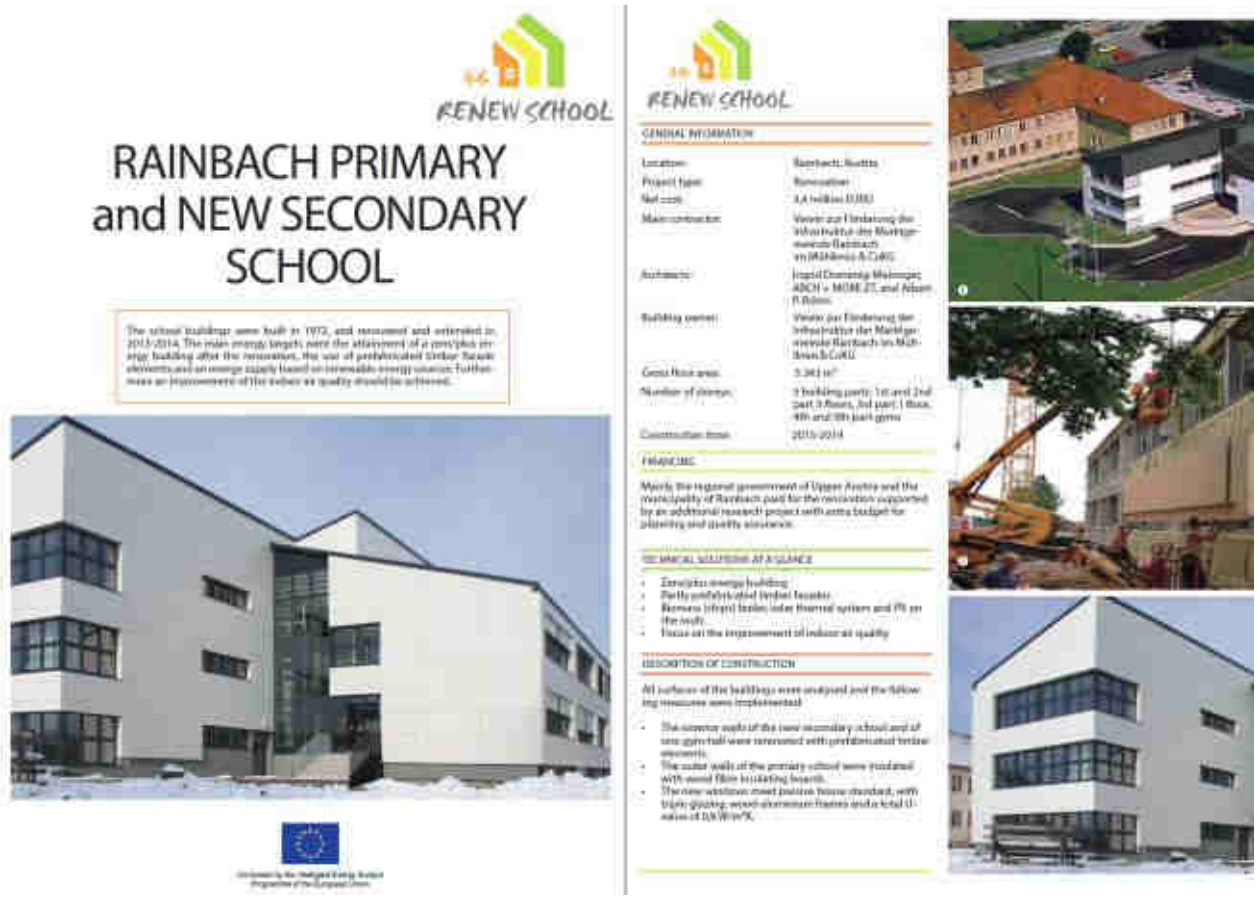


Figure 3 Frontrunner folder of the Rainbach school in Upper Austria

27 frontrunner visits and technical visits to other NZEB school buildings mostly accompanied with project meetings, workshops or technology talks have been organized and attracted 36 participants per visit in average. These visits to NZEB schools are in many cases the most important and successful instruments to convince school owners and decision makers of the importance for using new technologies and implementing high indoor quality. They can "touch" the building on-site and learn from the staff' experiences there.

Figure 4 Frontrunner visits Kalmthout / Belgium (first picture) and Neumarkt / Austria 2016

Find in Figure 4 and 5 two of the pictures made in Belgium and Austria on frontrunner tours in 2016.

The Lessons Learned from these frontrunner buildings, were compiled as a 12 pages brochure, which describes lessons learned regarding different financing and cooperation models, different degrees of prefabricated timber facades, challenges with market uptake, and chosen energy supplies.

3.2 Technical Workshops

The results of investigations on winning cooperation models and financing options as well as on winning technical concepts and energy supply were presented and discussed with the target groups in 20 technical workshops. Some of these workshops were organized together with other events. For example Swedish and Slovenian partners used synergies with technical fairs in the respective country. Some integrated it in national conferences like the National Energy Conservation Agency NAPE in Poland did. The City of Antwerp by its school administration organization AG Stedelijk Onderwijs Antwerpen organized a conference with parallel workshops on these technical issues, while the Danish Technical University and the Energy-Efficiency-Group of Politecnico di Milano used the annual AIVC conferences or Clima2016 conference reaching also scientific key actors. Three examples of the technical workshops held are given in the following.

On 27th November 2015 at Warsaw University of Technology was held a technical workshop. The workshop was organized together with XIII National Conference “Indoor Air Quality Problems in Poland” (http://www.is.pw.edu.pl/iaq/pop/pop13/popkonfa13.htm). The workshop was attended by 101 participants such as local researchers, designers, engineers, architects, school and local community-representatives, producers, and HVAC’s branch media.

Figure 5 The setting of the technical workshop at Warsaw University of Technology in Poland 2015

On 21st of October 2014 in Oslo a technical workshop was held. The workshop was organized together with Green Building Alliance (http://byggalliansen.no/nyside/). The workshop was attended by 81 participants such as contractors, engineers, architects, building owners, local researchers, financial institutes, school and local community-representatives and producers. There was high interest in the RENEW SCHOOL way of renovation.

Figure 6 A full plenum also in Oslo at the technical workshop with the Green Building Alliance 2014

On 30th June 2016 a technical workshop on cooperation models and financial solutions was held in Zugliano near Udine in the frame of the 5th Passivehause Congress of the Friuli Venezia Giulia regional Agency for Energy. 130 participants, both planners and companies heard about the RENEW SCHOOL model. In particular the Norwegian model on cooperation was compared to the Italian regulations on public procurement, and hints on financial resources used to finance renovation/construction of frontrunners were given. During the workshop the RENEW SCHOOL way of renovation was analysed also in relation both to the seismic regulation of Friuli Venezia

Giulia region that requires further improvements on structural elements, and for its application in relation to hygrothermal conditions. For the application of the RENEW SCHOOL way to hygrothermal conditions a representative of Fraunhofer in Italy, Mr. Gantioler, was invited at the technical workshop as external expert: during his presentation the WUFI model was presented and a simulation of hygrothermal conditions in building components and buildings under actual climate conditions performed.

Figure 7 Very interested public in a RENEW SCHOOL workshop held in the frame of a regional Passive House Conference in Friuli Venezia Giulia/Italy

3.3 Technology Talks

Technology talks have been carried out in the sense of short and focused presentation and discussion forums, attracting leading personal of the target groups to enter for example strategic partnerships between school financiers and companies. The concept and design of these technology talks for involving all important groups was agreed in the beginning of the project. The technology talks were aimed at getting school owners, architects and representatives of the building and construction industries/SME in touch with the RENEW SCHOOL renovation method of modular retrofit of existing school buildings. The needs of the target groups were in the focus. A series of these talks were held in addition to other events to initiate school renovation activities in new regions, with new companies, strategic partnerships, new cooperation models and new technologies.

Addressing these needs of the target group the results of the RENEW SCHOOL survey among stakeholders supported very much what was expected: When introduced to the general public as well as to specialised audiences, the system of retrofit with the use of prefabricated modules gets a very positive reception, but most owners and many architects are not familiar with this method of renovation.

Figure 8 Technology talk situation in Antwerp/ Belgium, 13th October 2016

In Belgium two such technology talks were organized during the project. The first one was in September 2015 during the Passive House days in Brussels together with Passiefhuis Platform (now Pixii). This technology talk focused mainly on owners and the industry. In Antwerp in October 2016 a second technology talk during a full study day on RENEW SCHOOL focussed on owners, architects and students in architecture (see Figure 6). The latter because it is important to promote the RENEW SCHOOL method also to the next generation of Belgian architects, the more so because construction in wood and timber facade modules is not a tradition in Flanders.

During the first part of a technology talk Vice - Mayor Claude Marinower, responsible for education, presented the new general Rational Use of Energy (RUE) goals of the City of Antwerp and AG Stedelijk Onderwijs Antwerpen. And as a possible means of achieving them, Marc Van Praet gave a general presentation of the RENEW SCHOOL project for prefabricated school renovations, presented the RENEW SCHOOL video and some of the findings of the survey for the "Owners' and Industries' needs report" which was handed out to all 106 attendants, followed by a short open discussion. 6 more of these technology talks were organized in Poland, Denmark, Austria, Italy and Slovenia.

3.4 School Projects

Students also play a vital role in reducing the school's carbon footprint and, importantly, its bills, with energy monitors patrolling the classrooms, making sure lights and equipment are switched off when not in use. The aim of the work with school users in RENEW SCHOOL was:

- To show and discuss measures and technologies for the retrofit of school buildings with the school users, both the pupils and the teachers;

- To involve students on sustainability themes like building energy efficiency, use of renewable energy sources and the use of wood as building material;
- To sensitize children about the themes above mentioned, let them know through the direct experience and knowledge;
- To give them instruments to measure the level of sustainability of their classroom and of their habits at home;
- To raise awareness of the positive role that each individual has in determining the quality of the territory in which they live and, globally, the future of the Earth, identifying and testing strategies for a sustainable living;
- To feed the curiosity and interest in the mechanisms by which nature sustains life on the planet;
- To support the development of the necessary skills to enable people to build a sustainable relationship with the environment: autonomy, creativity, sense of responsibility, the spirit of initiative, collaboration, the ability to design, ask yourself and solve problems.

The overall objective of the school projects carried out was to offer tools and opportunities to bring the younger generations to the issues related to sustainability of the development, support the growth of school communities with respect to the environment and the territory in which they are located, to support a cultural shift towards change of lifestyles and consumption aware, enthuse young people to issues of science and innovation, to develop the knowledge and skills needed for sustainable development for our planet.

In this context, our educational and teaching actions aimed to accompany students and teachers along a path of discovery and of personal and collective growth, in the belief that everyone, regardless of age and role in the community, can become protagonists of concrete changes and help the emergence of a community capable of a future.

One example of a school project in Slovenia is given in the following.

Name of the school:

Primary school Louis Adamic Grosuplje

Location:

Kopanj, Velika Račna 43, 1290 Grosuplje, Slovenija

Date of school action: 5th May 2016

Number of pupils involved:

27 (22 children, 5 teachers)

Design and description of the activities

Figure 9 Pupils involved in the Slovenian school project

Wood Industry Cluster Slovenia made a short presentation of RENEW SCHOOL project; with children we have talked about how they can save energy, we have shown them a short movie about that. We have also been talking about renewable energy sources. We have shown them different kind of houses (new houses,

public houses, prefabricated houses). Then we have presented them different energy efficient houses with their main characteristics (passive house, low energy house) - the “houses of the future”. We were talking about construction materials (wood, steel, brick, stones,…). We have shown the children what can be made of wood (bridge, bike, toys, houses, musical instruments, etc.). We have also shown them a prefabricated wall of one of the Slovenian wooden house producers.

After the presentation we have made a physical experiment with white and black bottle, they were making solar models, and at the end they were making toys from wood. Additionally we have shown them two movies: “Wood is good!” and “Energy, let save it”

It was very interesting for the children, because they could touch wood and they were comparing it with stone (the wood is nice to touch, it is warm). It was a great experience for them. This kind of project could be really helpful and adopted by teachers more often.

Figure 10 Different perspectives on one Slovenian school project

All in all 17 school projects involving around 3.180 pupils in 7 counties were made during RENEW SCHOOL.

3.5 Trainings

The organization of trainings on specific themes related to wood and prefabricated elements has kept the partners of the consortium really involved in this activity. Everyone had to fulfill the training objectives’ and worked in great synergy in developing common contents and topics to be presented in the different trainings.

A common sharing of contents has been made available to the partners and each one has decided to organize the courses upon the demands, the target of professionals/SME and the availability of the teachers and speakers.

The aim of these activities was:

- To create and implement specific trainings on the themes related to timber construction, prefabrication processes, ventilation systems, the use of RES in existing buildings;
- To allow SMEs and professionals to attend specific workshops, trainings and webinars;
- To update the skills with new information related to sustainability and to technical themes;
- To set up specific trainings that can be repeated after the project;
- To involve experts in participating to specific workshops.

At the end of the project a high number of professionals coming from different SME has participated and attended the proposed trainings (50 trainings organized with the participation of 1448 persons), which has contributed in disseminating the results and the aim of the project itself.

Some of these trainings and workshops will go beyond the project and will continue in training new professionals on these specific topics.

One example of a training course in Austria done by Holzcluster Steiermark is given.

On 28th of February 2017 Holzcluster Steiermark together with Austrian office for foreign trade in Zagreb, Austrian Ministry for Agriculture and Croatian chamber for Architects organized in Zagreb/Croatia a technical event with a focus on Building with wood – divided into three panels:

1) Architecture meets building with wood;

2) Retrofit is a building task of a future;

3) Technical solution for timber constructions.

Target group were Croatian decision makers from building sector, mayors, school directors, builders, investors, property developers, planners, architects, designers, etc. More than 118 participants attended the event. Presenters were on the one hand 14 Austrian experts/companies representatives who introduced technologies, products and methods on prefabrication, building and retrofits with wood, and on the other hand Croatian decision makers, planers and investors who introduced market potential for application of timber construction. The event was officially opened by Mrs. Prpic, state secretary of Ministry for Building and special planning. The training was free admittances.

Figure 11 Invitation of one successful training in Zagreb organized by Wood Cluster Styria in Febr. 2017

3.6 Diversity in School Design

Is there a better place to drive change than in school?

A review on the interviews within the Diversity in School Design initiative of the RENEW SCHOOL project.

Figure 12 Ledina Grammar School Ljubljana. Renovation of the unused secondary entry 2013, Architecture: Ana Kreč and Ana Kosi - partners of the Svet vmes office. Picture: Matevž Paternoster

A successful school building renovation bears a high multiplier potential. The key issue is the user satisfaction. If teachers and students feel comfortable, the energy-oriented renovation is regarded as successful and is transferred to private households and to the public via numerous `messengers`. However, user quality and satisfaction are `soft` factors (compared to energy-technical indicators) that usually are on the bottom of the priority list when it comes to the technical economic optimization of a school renovation and thus the potential gets lost to achieve a multiplier effect. A successful school renovation is thus `only` an improvement of the energy efficiency. School and learning has to change just like our society changes. New pedagogic concepts are needed, which, however, need new space concepts in order to guarantee the quality of use. The user's acceptance is based on the identification with the building. This identification can only be achieved by the opportunity to participate. An alleged stretch squeezed in a tight corset of a school renovation.

A series of interviews were made within the RENEW SCHOOL Project. The aim was to show architects and experts the future oriented approach for the solution of this dilemma in school renovations and to introduce them to the public in the frame of a platform.

The findings learned in the interviews clearly showed the architects' and the contractors' responsibilities. The ones in their function as creators and coordinators in planning and realization and the others in their function as customer. The builder as customer is responsible for the objective of the renovation. Later corrections and unprecise wish lists are the cost drivers in every renovation. On the one side there are the architects, whose responsibility it is to create high-quality constructive and functional quality. Both sides builder and architects are responsible for the process of planning and realization of a school renovation, which is after all an important social responsibility.

The consideration of diversity as the basis for the planning also means to realize a diversity in the claims of utilization. There is no isolated or subsequent participation in connection with user quality. Especially in the tight financial corset the requirements to the `new` school must be negotiated with everybody. `Everybody` does not only mean the users, but also the builders, the authorities, the facility management, the planners and the executors. Each actor has to bear his own responsibility for his specific function. The process requires multiple competencies, both on the expert side and in the process design. The school renovations discussed in the interviews chow, that this stretch is possible: successful school renovations does not necessarily have to cost more, however, it needs a brand new planning process.

3.7 Events

From May 1 to October 31, 2015, a world exhibition took place in Milan with the main topic "Feeding the Planet, Energy for Life". 145 countries and international organizations took part in this EXPO. On the occasion of the Styrian Day on 12 May, eEEG group - Energy Department of the Politecnico di Milano, Holzcluster Steiermark and AEE INTEC organized the "RENEW SCHOOL Training" in Austrian pavilion. The training was attended by 45 participants from Italy, Austria and Slovenia, mostly representatives of companies, architects, designers, engineers and public institutions. The main objective of the event was to refer about technical concepts and possibilities for public retrofits with wooden prefabricated elements, as well as exchange of experiences between Styrian, Slovenian and Italian experts. In the evening of 12th May there was an invitation of the regional Styrian government also for all RENEW SCHOOL partners to attend a business reception in the UNIQUA tower in Milan.

The URBAN FUTURE global conference is the World's largest meeting point of City Changers: committed people that actually drive change to make cities more sustainable. The last conference was organised in Graz from 2nd - 3rd March 2016. 1.500 participants from 300 cities participated in the conference. Within the framework of the workshop "The sustainability turnaround: would the change actually be so easy?" HCS and AEE INTEC used the possibility to present the project and "RENEW SCHOOL way" of renovation.

Figure 13 Big plenum of the URBAN FUTURE global conference, Graz 2016; photo credit: Gerald Babel-Sutter

RENEW SCHOOL at “Zukunftsraum Schule” conference Stuttgart 2015

The “Zukunftsraum Schule” conference takes place every two years and is organized by the Fraunhofer Institute for Building Physics IBP together with other partners. The conference is well known and highly recognized, attracting over 600 participants in 2015. To promote the RENEW SCHOOL project a poster exhibition presenting six posters about RENEW SCHOOL and two posters with detailed information on the German frontrunner schools (see Figure 14) were displayed in the main conference room during the two days of “Zukunftsraum Schule” conference. In addition to that, Armin Knotzer from AEE INTEC had the possibility to talk about the project during a parallel session of the conference (see Figure 15) in front of 125 signed participants.

In the frame of the RENEW SCHOOL 34 events were held additionally to the technical workshops, frontrunner visits and technology talks, were members of the consortium presented the idea and results of the project.

Figure 14 Picture of a part of the poster exhibition promoting the RENEW SCHOOL-Project at the "Zukunftsraum Schule" conference in Stuttgart 2015

Figure 15 Picture of the presentation Armin Knotzer (AEE INTEC) held during the "Zukunftsraum Schule" conference in Stuttgart 2015.

4 Results and reports

4.1 Technical Signpost

The technical signpost was written and based on the information about the frontrunner buildings. The aim of the technical signpost is to give examples of technical solutions applied in schools that are shown to perform well with respect to achieving high classroom environmental quality with low energy use, which are robust, tested and verified. It is expected that these solutions become an integral element of the future energy renovation campaigns carried out in conventional schools and kindergartens. Technical signpost is disseminating lessons learnt, warning about the potential risks, and educating building stakeholders on which solutions to be used. It is thus creating the guideline and the reference for the future school renovations.

The technical signpost developed in the RENEW SCHOOL project summarizes the data from the 19 frontrunner buildings and includes the following four broad categories pertaining to building construction and installations: (1) timber prefabrication; (2) ventilation; (3) daylight and daylight control; and (4) energy sources including renewables.

In case of timber prefabrication, two types of facades are described to make the building shell resistant against moisture from outdoors, from indoors and from moisture trapped during construction process. Facades with ventilated cladding employ a two-step sealing principle based on a ventilated air gap separating the external cladding from the wind barrier and insulation and thus keeping the construction dry. Facades with non-ventilated cladding employ a one-step sealing principle based on a watertight outer barrier; the moisture diffusion abilities of the used materials ensure that the structure is kept sufficiently dry. It is advised that a vapor barrier must be used to protect the timber element from the moisture from indoor sources. Adhesive seals must be used to join the existing wall and the timber element in the window opening. A leveling (compression layer) that absorbs the irregularities of the existing façade should be used, as well.

In case of ventilation, it is advised that ventilation should always be provided and should have the capacity to address peak loads during the day. This capacity should also allow the nighttime ventilation. Mechanical ventilation systems and hybrid systems are to be considered as the ventilation solutions. The former draws the air through the air handler that allows filtering, heating the air and energy recovery from the exhaust. To operate properly the system must be balanced, controlled by CO_2 sensors or any other relevant sensors indicating the demand, noise and vibration isolated and should secure proper intake and exhaust avoiding cross-contamination. Central systems can be used requiring the space for the ductwork or decentralized, where the air-handling unit is located in the classroom. The latter hybrid system combines the mechanical system described above which is using mechanical forces to draw the air with the system that is using natural forces of wind and pressure difference. Hybrid systems allow reducing operation and maintenance costs but require that the ambient air be of a high quality. Both systems can be used for achieving nighttime ventilation that allows to increase the airflow to remove the accumulated heat once the temperature difference between outdoor and indoor air >3K.

The Figure 16 shows the CO_2-concentration of front- and “backrunner” schools investigated in the frame of the RENEW SCHOOL project.

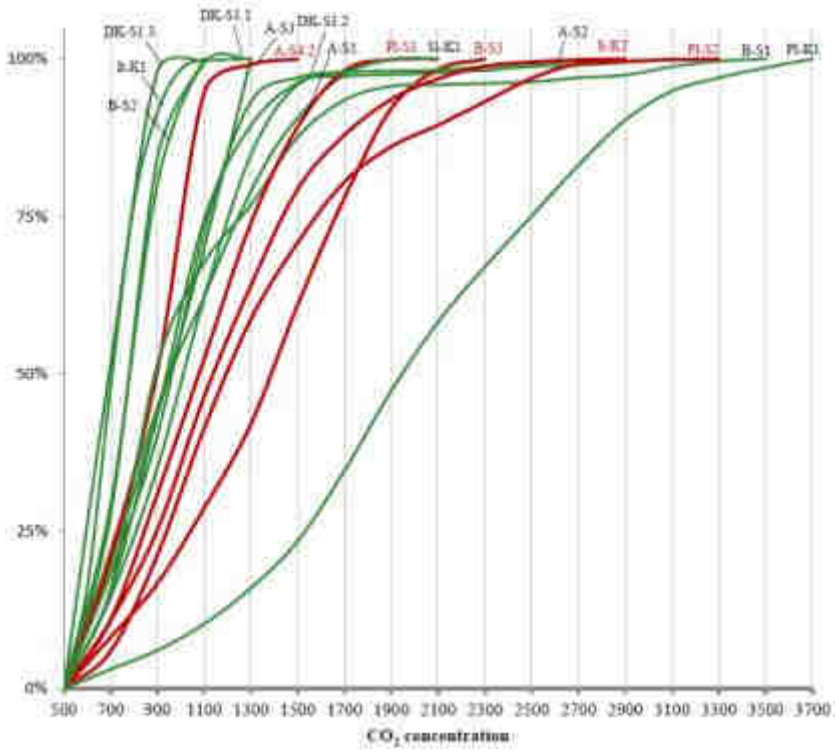


Figure 16 Cumulative distribution chart showing % of time with carbon dioxide (CO2) concentrations below or above certain level; green lines show CO2 concentrations in frontrunners and red in the reference conventional buildings. There is a systematic difference in the measured conditions between the two different types of buildings, CO2 concentrations being generally lower in frontrunner buildings

In case of daylight and daylight control, it is advised that the design should maximize the income of daylight on overcast days and minimize darkening effects through shading elements and surroundings. To support such design the window-to-floor ratio is recommended to be above 18% i.e. a façade opening ratio should be ca. 42% (see also Figure 17 on this).

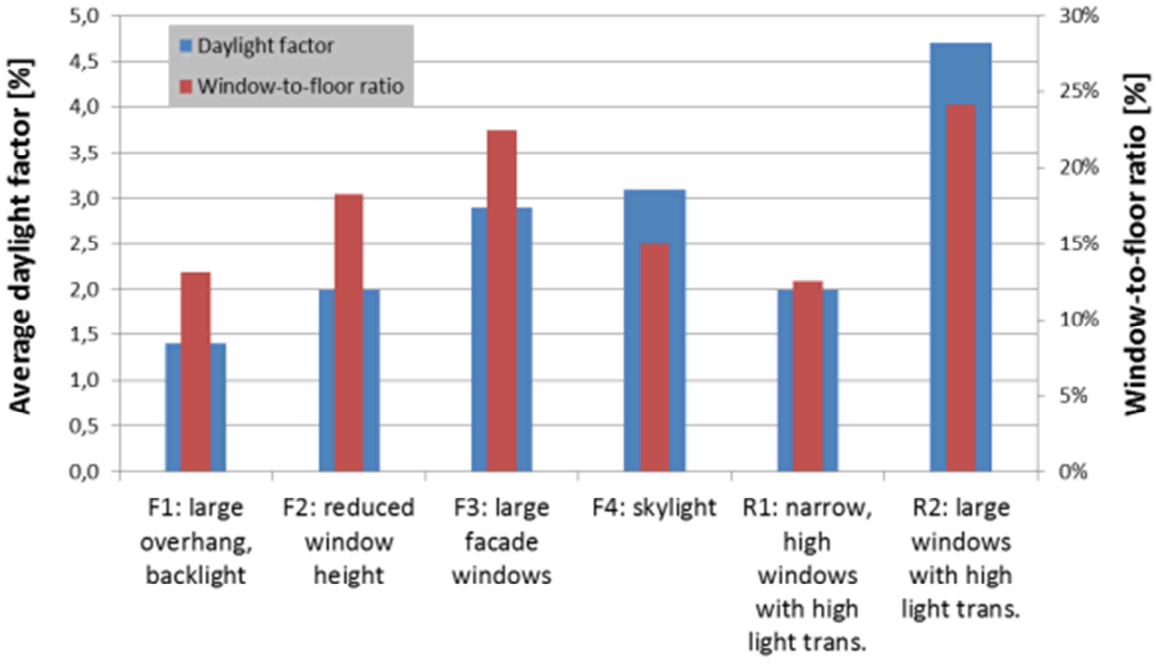


Figure 17 Different daylight situations investigated for different classroom types of frontrunners

High windows should be used and glazing with solar coating requires higher window-to-floor ratios. To reduce the need for large façade windows and to cut down the heat loads skylights are advised for use. External light-colored blinds for shading are recommended as they allow diffuse light to enter even when activated. Overhangs are not recommended. Glare should be dealt with by manually adjustable screen/blinds mounted internally.

In case of energy sources including renewables, use of heat pumps, photovoltaic systems, gas boilers, biomass systems and district heating is recommended (see Table 1). The advantage of integrated systems is that they allow effective use of energy and respond to peak demands: As the energy demand is reduced because of the energy retrofit, renewable energy sources can be integrated and smaller size components can be used. Heat pumps provide energy for heating and cooling. Low temperature heating is possible with high coefficient of performance, while coupling with geothermal heat sources (installed under schoolyards and schools) allows optimal seasonal performance. Photovoltaic systems support the energy production for heating and domestic hot water. They can be installed on roof, integrated with the facades, or as fixed shading components.

Table 1: Summary of the main energy systems and renewable energy systems installed in the frontrunner buildings

frontrunner / country	***heat pumps***	***gas boilers***	***biomass system***	***district heating***	***PV***	***solar thermal***
1 - Nor	●					
2 - Nor	●					●
3 - Nor	●					●
4 - Swe	●				●	
5 - Bel	●	●			●	
6 - Ger				●	●	
7 - Ger				●	●	
8 - Aus			●		●	
9 - Aus		●	●		●	●
10 - Aus			●		●	
11 - Aus			●		●	
12 - Slo	●	●				
13 - Slo	●	●				
14 - Slo				●		
15 - Slo			●		●	
16 - Pol		●				
17 - Den		●			●	
18 - Ita	●				●	
19-Bel		●				

Biomass systems provide also the energy for space heating and domestic hot water, but need locations where wood and other biomass source is readily available and managed in an environment-friendly and sustainable way. The system requires biomass storage with an access to air for combustion. Gas boilers can be used in connection with other thermal systems to deal with the peak loads; they operate usually at ambient temperatures <0°C. They make it possible to operate the heat pumps at constant load thus at the high coefficient of performance.

4.2 Financial Signpost

Data from identified frontrunners of the RENEW SCHOOL project was collected to get an in-depth understanding of the composition of funding sources as well as complexity of cooperation models, renovation process and experiences with the use of prefabricated timber technology. To this end, tools used were: survey questionnaire,

individual interviews and visualization tools. The survey questionnaire was suitable in order to generate data on the frontrunner cases by asking different key actors involved (project manager or owner and investor, architect – planner and the main contractor). Additionally, the interviews were appropriate to get an understanding of the unique approach/experience of each project.

In total, twenty four respondents answered the survey and interview. The funding in the frontrunner cases was from a combination of sources, mainly public but more and more also private capital, complemented in a small way by formulas like ESCO. To solicit additional funds, the projects sometimes specifically aimed for frontrunner goals like the Passive-House standard. An example of Warsaw mentioned a PPP-Energy Performance Contracting solution for up to 30 schools. Whatever sources were used, they were bound to requirements. Nearly in all projects the time needed to develop the financial model took several years.

The Financial Signpost report summarized the wider available financing opportunities for sustainable school renovation, as well as on cooperation models. These focus on funding possibilities, new financing methods, enablers for financing as well as general advice, findings and requirements. A final part of the report consisted of analyzing the cooperation models used in the frontrunner school renovations. Strengths and weaknesses were identified:

Strengths	Weaknesses
1. Internal driving forces (e.g. motivated persons) pushed the project and innovative ideas (such as prefabrication) for a long time in order to realize renovation. 2. Extended design phases provide optimization options. 3. A central source of data proved to be beneficial for the project processing. 4. Personal meetings and dialogues in the beginning foster mutual cooperation in the team that is necessary for thorough information handling and frictionless procedures.	1. Communication and information management between partners was lacking behind expectations. 2. Experts (passive house/timber manufacturing/ HVAC) were not integrated from the beginning. 3. No standardized documentation for the building itself and possible 'learning curves'. 4. The introduction of the users after renovation was dominated by technical experts less experienced to explain the functions in an understandable way. 5. Lowest price principle typically used as a main driver for the designation of cooperation partners (especially of the contractors). 6. Less importance given to the architectural design.

This analysis lead to the following lessons learned:

- The implemented cooperation models (Renew School cases) neglected possible optimization options, and room exists for improvement in development and optimization of cooperation models.

- A typical cooperation hurdle is un-optimized information exchange and communication between cooperation partners.
- Recognized challenge (in the Renew School cases) of getting all actors for planning and implementation to cooperate efficiently together.
- In cases, the design and planning team worked together without knowing who will be the executing contractor. This causes problems. It is important, especially when prefabricated elements are used, that contractor's capabilities are known by design and planning to avoid possible mismatch.
- Uncertainties during design and planning phase have an influence on the construction phase and cost time, quality and money.

Focusing specifically on timber frame prefabricated construction, the following lessons were formulated:

- Using prefab elements led to a reduced on-site execution time and improved construction quality, as experienced by the involved actors.
- A lower construction cost and easier project management was also achieved.
- An energy consultant or municipal representative was often a driver to choose for prefab.
- The majority of cases used an integrated solution, including insulation, air-tightness, windows and cabling all prefabricated into the walls.
- The most advanced solutions even integrated shading systems, internal finishing and came with pre-installed fixation points.

To further support of new school projects, a the "Financial Signpost" leaflet was published at the website that summarized all enablers for change in school building renovation, focusing on cooperation models, best practices and financing.

4.3 Decision Tool

An interactive web-tool was launched to guide decision makers in choosing between fundamental options, each with their advantages and limitations. The main decisions to make:

- You can renovate your building in a traditional way where the on-site travel period lasts much longer than a traditional summer school holiday period.
- You can renovate your building in an innovative way during the long summer holiday period.
- You can choose to build a new building on the current school site.
- You can move permanently to another location.

The tool (front page see Figure 18) can be found on: http://schoolrenovatie.be/en/homepage/

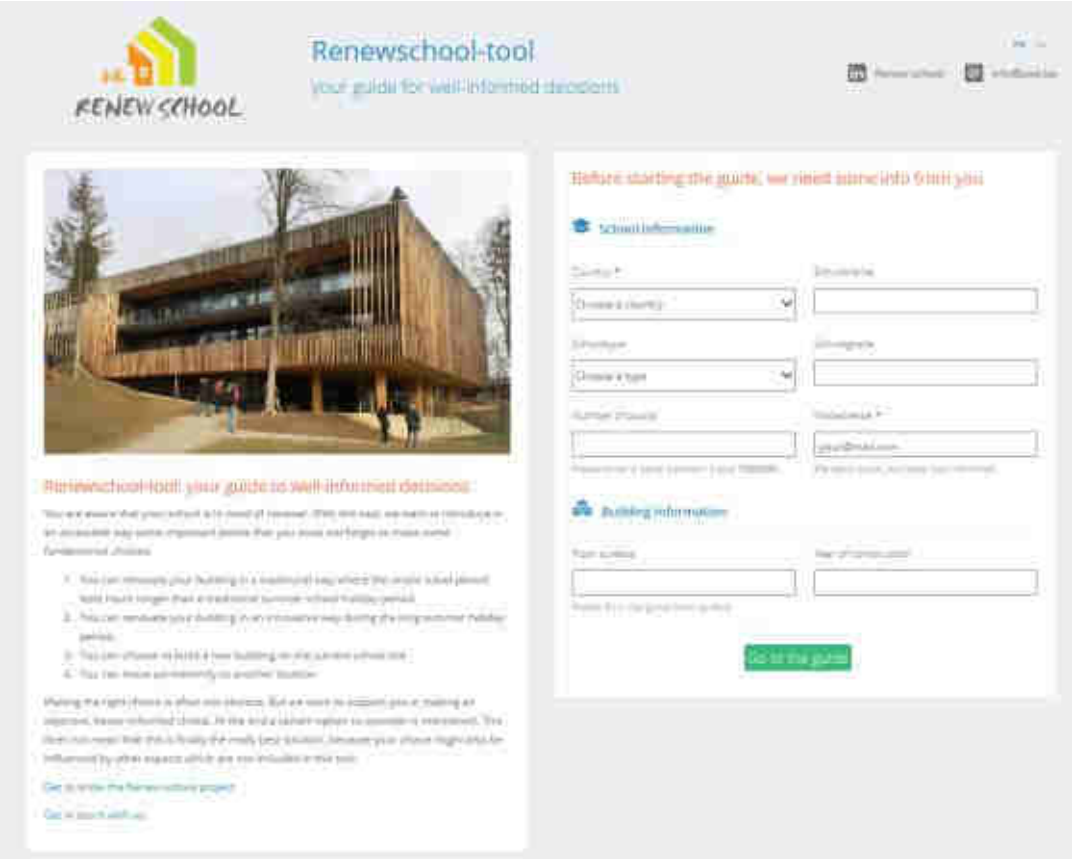


Figure 18 Front page of the web-decision tool developed in RENEW SCHOOL

A roadmap for guidance after a decision for prefabricated timber and nZEB school renovation is provided in the end of the decision tool process and can be downloaded at the website at “Qwner of schools” section.

4.4 Owners and Industries’ Needs

Our main question before starting the survey on modular renovation in the target groups was:

Which triggers and obstacles for market uptake of the “RENEW SCHOOL way” of renovation with prefabricated modules can be detected from the perspective of three stakeholder groups in the renovation of school buildings: the users, the owners and the construction and building industry?

On the basis of an EU wide survey on which 400 respondents gave answers, it was possible to conduct a report on this. For a number of questions and related results owners and managers of school buildings (collected under the heading of ‘maintenance’) were put together to have a larger sample. This of course not for questions that were different for the two categories. With 126 users, 70 owners and building managers and 185 companies it was possible to get a fair view on the average responses of each respondent group.

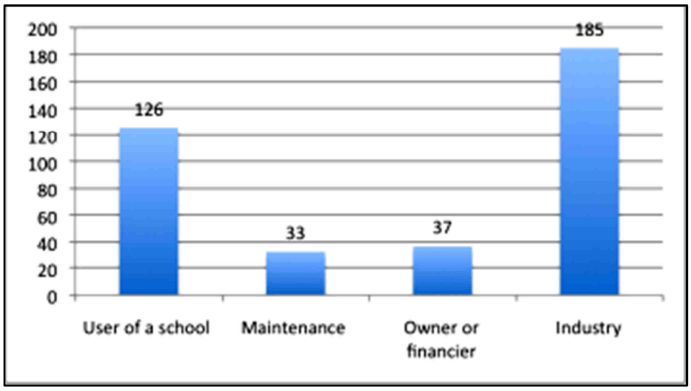


Figure 19 Type of respondent in absolute number, N=400

In the following, some of the results are given. After having shown the RENEW SCHOOL video prepared for the survey, the perception of the users on how they thought the indoor air quality in the renovated school buildings had changed was checked.

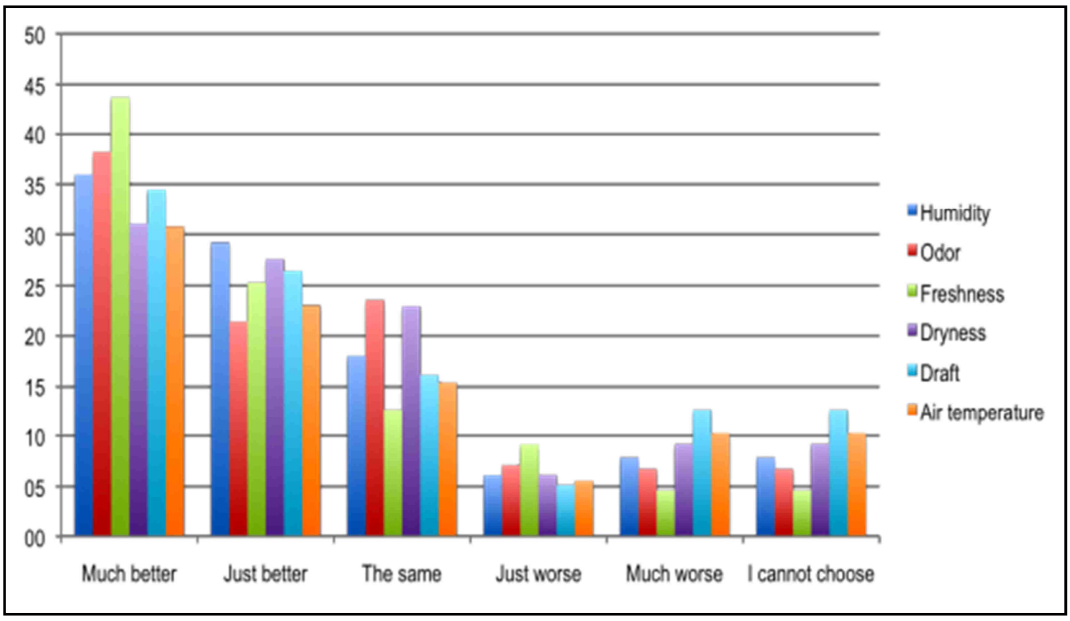


Figure 20 Perception of Users – Indoor Air Quality of Renew School renovated schools in %, N=86

Although this just represents the perception of users of the effect of modular renovation of school buildings the result is quite convincing: on all aspects of indoor air quality users consider modular renovated schools to score much better or better. Almost 70 % thinks that the freshness of indoor air would be much improved.

We received the investment cost for the owner of the school building(s) (without VAT) in € / m^2 GFA in typical modular renovation projects.

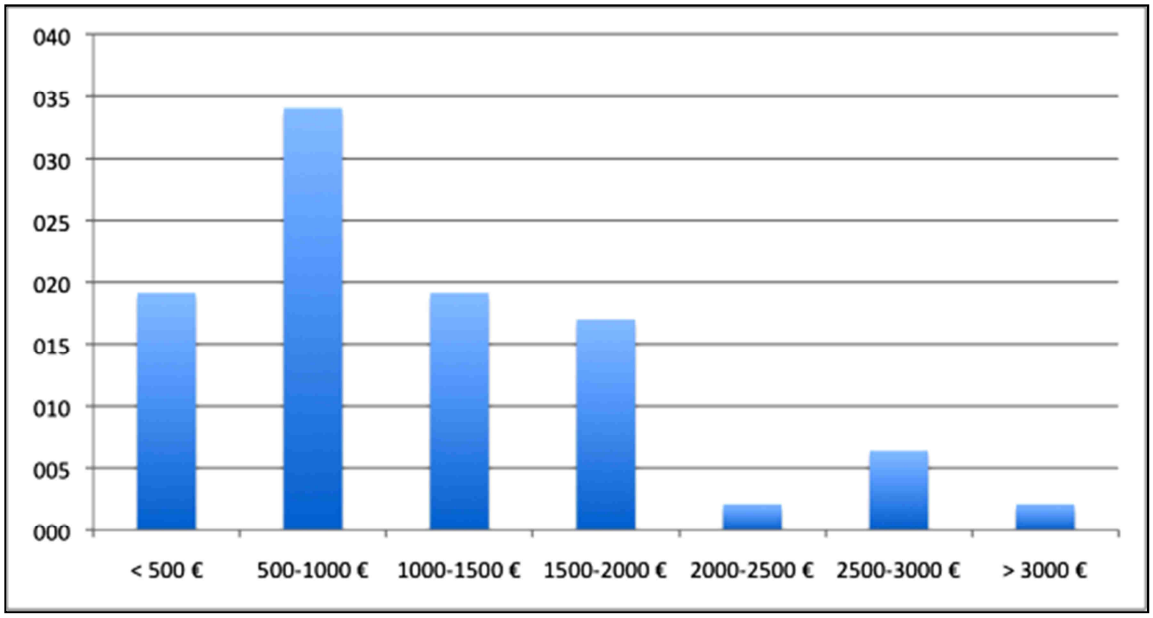


Figure 21 Industry Price range in €/m2 GFA without VAT in %, N=47

Of the 47 answers we received, the median cost per m^2 GFA without VAT would be between 500 and 1000 € / m^2 GFA. The cheapest cost would be in Poland, the highest in Norway. This is probably due to the very big difference in labour costs during production and on-site construction.

The results of the SWOT analysis, combined with interviews with stakeholders, led to the following recommendations that might be interesting for owners and investors on the market-pull side and for the wood construction industry if they would want to push this market forward.

Recommendations to owners and investors

- When investing in a deep renovation of your school buildings, consider prefabricated modular renovation: you will not have to move school teams to temporary housing and you will save immediately on moving costs and in the long term on heating and maintenance.

- To attract pupils and students: invest in modular renovation during school holidays for energy savings, good indoor air quality and modern looking school buildings… all possible within one and the same election or budgeting period

- Stay ahead in the "education market": which parent or student will choose an "old" school if a modern looking one is also available?

- With Renew School retrofit you stay ahead of the regional, national and European rules on energy consumption and ecological footprint. With prefabricated façade and roof modules you can reach nZEB of even Energy+ standards.

- Capital for investment in public property and energy savings is cheap at the moment.

- ESCO's and building companies are looking for opportunities for Public Private Partnerships

Recommendations to the industry

• Emphasize the short renovation on site during school holidays: owners as well as users consider this to be the prime advantage of modular renovation for schools.

• Create a reliable cost / profit model to compete in the regional market with existing traditional renovation methods & constructors.

• Include in your business model the savings for the owner by not having to move pupils nor rent temporary housing. It will make it competitive, even if somewhat more expensive per m^2 GFA.

• Keep amortization of the investment under 20 years.

• Invest in reliable regional information for investors on how a modular renovation method can comply with standing regulations (fire, indoor air quality, seismic dangers, insurance…)

• Find ways to ensure life-long quality while significantly lowering cost under the level of traditional renovation.

• Create a regional standardized model for public procurement and a permanent link with regional investors and research institutes.

4.5 Initiated Schools Renovations

Two examples of initiated school building renovations are given in the following, representing most important developments of renovated schools during RENEW SCHOOL project: Scuola Media Alessandro Volta, Italy, and Berufskolleg Detmold, Germany

Scuola Media Alessandro Volta

Figure 22 Renovated Scuola Media Alessandro Volta, municipality of Cologno Monzees, Italy

Supported by the Italian programme "safe schools, beautiful schools", which aims at improving the buildings resistance to earth quakes, the secondary school A. Volta at Cologno Monzese close to Milan was retrofit in 2015. It is currently used by around 483 pupils of sixth to eighth grade. The aim of the renovation was to reduce heating demand, so the impact on the environment, and improve indoor air quality. Another important aim was to stabilize the building in order to make it save in case of earthquakes. Year of construction was 1977.

Gross floor area: 3400 m²

The transmission value of the outer walls was reduced from 1,64 W/(m²K) to 0,11 W/(m²K), which reduces heating demand by about 45 kWh/m².a

Heating system: Radiators supplied by gas central heating, hot water from a central unit

Seismic Security:

Walls and structural elements have been enforced at strategic positions, in order to make them absorb vibrations. Moreover, metal plates have been added to strenghten the joint of column and beam. Prefabricated elements made of wood also increase seismic security: Wood can absorb vibrations, and can thus be used in combination with steel.

Ventilation

To improve indoor air quality, windows have been planned such that they can be easily used for ventilation. Moreover, the pupils have been trained one month long in the project Air@School to provide for a decent air quality by adequate window opening. In two classrooms CO_2-sensors show when ventilation is necessary. The training activity was conducted by the association Energia di Classe (www.energiadiclasse.com) in cooperation with eERG-PoliMi, in the framework of the RENEW SCHOOL project.

External movable solar blinds have been installed to prevent overheating and glare.

Financing and Support

Project volume: about 1 million EURO

The renovation has been financed by the community, with support from a regional fonds and the national programme "Safe Schools, beautiful Schools" (“scuole sicure, scuole belle”). The technical office of the community has made the planning and supervision of the works.

Construction

The building was covered by wall elements made from glulam construction and filled with mineral wool. The facade is ventilated, the outer cover elements are made of resin bound wood or paper fibers with a weather proof coating. In this case, the thermal envelope has been added layer after layer on the existing building.

Contacts

Technical office of the community (Ufficio Tecnico Communale) Cologno Monzese:

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Berufskolleg Detmold

Figure 23 Renovated façade of the vocational college in Detmold, administrative county of Lippe, Germany

The renovation to plus energy school was concluded in 2016. The school center, formed by „Felix-Fechenbach-Berufskolleg“ and „Dietrich-Bonhoeffer-Berufskolleg“ is used by about 3600 pupils and students aged from 14. The vocational college offers specific engineering studies like electrical, information, wood, metal and supply engineering, complemented by studies on nutrition, health care and welfare. The new building is a demonstration project in the national program for energy efficient schools, “Eneff Schule”. Winner at the ideas competition “School 2030 – Learning with energy” in the category “master plan in renovation and innovative lighting system”.

The campus consists of 3 bar-shaped buildings, built in the years 1954 to 1962. Prefabrited timber elements were produced on the basis of a 3D-scan of the building and mounted on the existing masonry. Motivation for renovation was deficits in the energetic situation as well as visibly in bad repair, changes wanted in the interior design.

Gross floor area: 14.300 m²

Heating demand, electric energy demand, end energy demand

21,3 kWh/m²GFA.a / 8,5 kWh/m²GFA.a (energy demand for electricity, ventilation and auxiliary energy) / 35 kWh/m²GFA.a (final energy demand including hot water)

Lessons learned

Fast, smooth and cost-efficient renovation due to using prefabricated timber elements. Insulation material made of cellulose can be blown in to form an ideal bond between old wall and timber element.

Financing and Support

Project volume: about 6.7 million EURO

The administrative county of Lippe as building owner paid for the renovation and organized itself as managing capacity. Support comes from the German federal ministry for economic affairs and energy. Main contractor was Brüggemann Holzbau GmbH & Co. KG und Krebbers GmbH & Co. KG. Construction time: 01/2014-03/2016

Building technology

A hybrid ventilation concept ensures the appropriate ventilation of class rooms. Generally, decentralized ventilation units are used in combination with natural ventilation by window opening. The heat recovery factor of the mechanical ventilation units is around 85%. Like before the retrofit, district heating with high share of biomass is used for room-heating and domestic hot water. Existing radiators were kept and are now operated at a lower

temperature. Heat comes primarily from a cogeneration plant. To reach an energy surplus an integrated solar roof made of mono-crystalline solar cells was installed. The photovoltaic plant reaches 352 kW_p with a total area of 2.768 m².

Construction

Prefabricated timber elements have been used on facade, roof and top floor ceiling. The timber frame construction parts were delivered to the building site without windows and plastering, and mounted on the existing walls. Then the cellulose insulation material was blown in. The outer walls now reach a U-value of 0,11 W/m²K.

Contacts

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4.6 Lessons Learned

About Cooperation and Communication

The cooperation analyses identified the following necessities and learnings:

- Having **a strong driving force** behind the project can be crucial in persuading the project to use prefabricated timber elements.
- Having **an extended design phase** after the contracts were established (see 'P' and 'C' in Figure 24) allows the architect, engineers and contractors to optimize the prefabricated elements and the solution set, as demonstrated in the frontrunner renovation project of Søreide primary school in Norway. It will reduce the number of changes that might occur during the construction phase and thus also the final cost of the project.

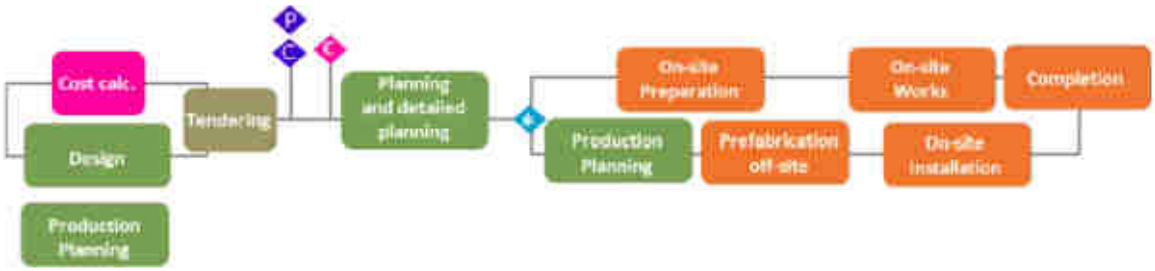

Figure 24 Action chain of the renovation in Søreide (primary school in Norway)
*P – Contract, planning team, C – Contract, contractors, € - Cost statement, * - Design freeze*

- **Integrated planning** with the building owner, architect, structural engineer, designers, mechanical and electrical installations and management of the construction is crucial to ensure an optimal final result.
- The usage of a **central information sharing system** or **cloud program** for the project management can prove to be beneficial for project progress and cooperation.
- **Personal meetings and dialogues** enabled a better mutual understanding and induced consequently a better atmosphere of trust and confidence.
- **Teachers** should be encouraged through **participation** so that they can stand behind the project.

- The **information flow between design and execution** or the integration of experts in early planning phases is crucial, resulting in short construction times, trouble-free renovation process and school operation.
- **Precise and understandable documentation** of how to operate and maintain the building must be handed over to the users in order to be able to take advantage of a high quality renovation.
- The public procurement regulation force the 'lowest price' principle, but optimal solutions often require specific experience and capabilities. The tender should thus identify the required capabilities necessary to realize the proposed solution. The disadvantage of this approach is that there is less room to think about an alternative solution that might be even easier to realize.
- For deep renovation, there is a **risk of the tender being fragmented**. This can result in sub-optimal situations and end products if the different partners do not exchange information and communicate sufficiently in the early stages of the planning process.

About user comfort and monitoring of frontrunner Schwanenstadt

In the first month of operation from 2007 the teachers criticised the overheating in the classrooms. So in summer 2007 the originally planned but in the first month of operation not mounted exterior shading system and in 2009 a night ventilation system was installed. This "natural / free cooling" system includes:

- External shading (exterior blinds) (see Figure 25 Missing external shading in the first year (left picture) caused overheating in the classrooms of the New Secondary School Schwanenstadt. As reaction to this an external shading system was installed in the second year (right picture).
- 25)
- Door checks for classroom doors (small crack of the door during the night)
- Classroom window wings – special locking (small crack during the night)
- Atrium window air vents – open automatically if room temperature is above 23°C and outside temperature is below 21°C
- Ventilation devices start automatically in exhaust-mode
- Procedure stops if room temperature is below 18°C

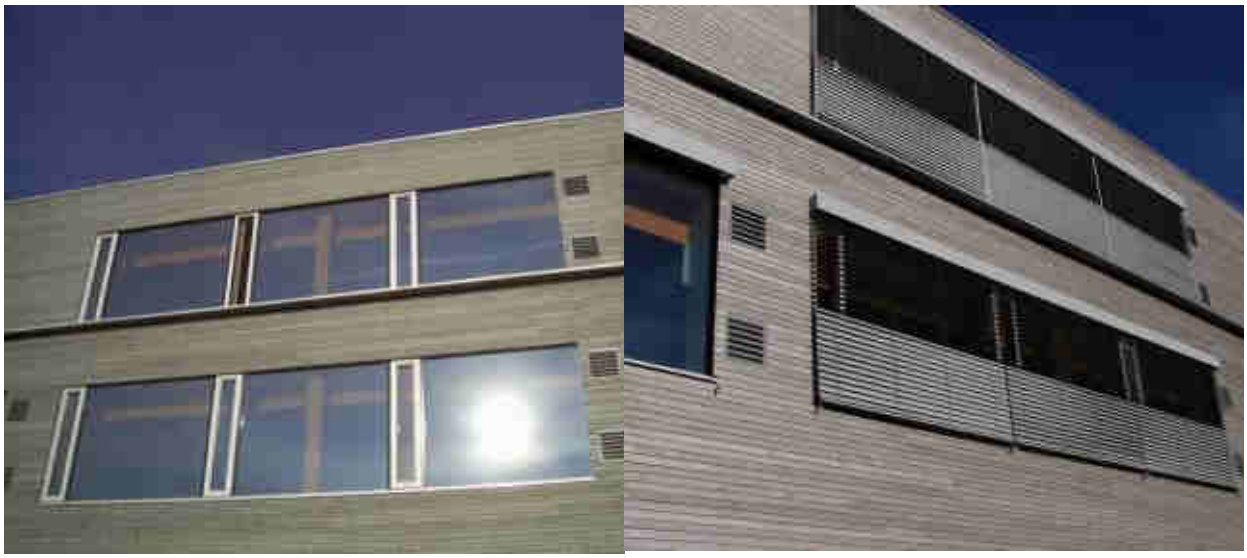

Figure 25 Missing external shading in the first year (left picture) caused overheating in the classrooms of the New Secondary School Schwanenstadt. As reaction to this an external shading system was installed in the second year (right picture).

During the operation of one prefabricated wooden demo-element installed onto the exterior wall of one classroom, which was installed in 2006 and measured until 2007, the decentralised ventilation unit was too loud and disturbed the lessons. The problem was seen in the missing housing of ventilation unit (see left picture in Figure 26 Missing housing of decentralised ventilation units caused sound problems in the first operated model classroom (see left picture). The housing was installed regularly later (right picture) to improve the situation in the classrooms.

26), which was installed in every unit later on (right picture).

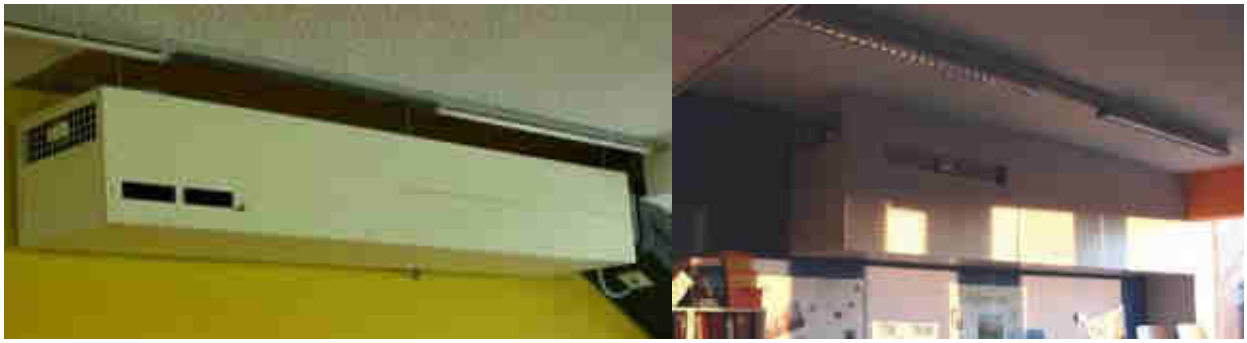

Figure 26 Missing housing of decentralised ventilation units caused sound problems in the first operated model classroom (see left picture). The housing was installed regularly later (right picture) to improve the situation in the classrooms.

In the end of the construction phase a meeting with all teachers was organised to inform the users about the renovation and the technical features of the renovated building, including also a personal instruction. Some of the teachers mentioned that this information was too little, others said that they are not responsible for the maintenance of the mechanical ventilation system, and therefore they don´t want to deal with this issue. Now, around 10 years after these interventions, most of the pupils and teachers - a couple of them changed in this

period, including principal – are very happy with this renovation, this could be seen during the RENEW SCHOOL frontrunner visit in Schwanenstadt on 4th April 2016, where 60 interested participants attended.

About challenges in constructions for renovation in Sweden/the North?

During the search for Swedish frontrunner buildings for the RENEW SCHOOL project, no schools were found to be renovated with prefabricated wooden façade elements. Upon further investigation it was found that the regulations regarding the construction sector in Sweden as defined by Boverket's Building Regulations (BBR) includes the moisture safety regulation as follows: "if the material moisture level for a material is not well-researched and documented, a relative humidity (RH) of 75% shall be used as the critical moisture level."

Regarding external walls, the protection layers against rain and the ventilated air gap may be an exception for this criterion. This regulation seems to inhibit the use of prefabricated wooden facades in renovations as it is very difficult to ensure that the RH requirement is met, due to exterior weather conditions during installation, climatic variations, etc. A second bottle neck that may be inhibiting the use of said façade elements seems also to be the strong market for new buildings and the actual or perceived higher costs of renovation in the North.

In order to find the solutions for such a market situation, a technical workshop was held inviting various stakeholders in Gothenburg in September 2016. In the workshop it was that there is a barrier in the mind set of construction companies due to no example projects in Sweden. One preliminary investigation showed that applying one particular module design which had been used in Austria does not work in the west coast of Sweden considering the above mentioned moisture regulation. There is a strong need to develop a prototype of a module panel to be demonstrated. Such a demonstration could be done by laboratory test and actual installation of the panel under the real weather conditions. HSB Living Lab (https://www.hsb.se/hsblivinglab/) on the Johanneberg campus of Chalmers University of Technology is expected to provide such opportunities for research institutions and companies to test and demonstrate new products.

5 Conclusions and Recommendations

The overall majority of school owners, school users, planners and industry representatives are enthusiastic about the possibilities of the “RENEW SCHOOL way” of renovation method, but it is still very difficult to get this kind of modular retrofit started in the EU market. Main reason seems to be that owners are reluctant to invest in a renovation method for which they cannot find enough examples within their regional market, for which there are not enough local or regional experienced companies, for which there is no standardized public procurement method nor a standardized set of rules for government subvention.

The RENEW SCHOOL project tried to overcome barriers, brought financiers and professional contractors together, served as a platform for information and promoted high energy efficient comprehensive school renovation. 20 school building renovations of 12 different municipalities could be initiated by the project, but not all are using / used the modular way of renovation. If the EU wants to ascertain the market uptake of modular prefabricated renovation of school buildings as part of the EU efforts to lessen our ecological footprint, support will need to be given to the two sides of the market. Market pull could be enhanced through support by EU funding for pilots in regions where wood-construction is not part of the local building culture.

A combination of national, regional and EU financial support might convince owners to consider a RENEW SCHOOL type of renovation. On the market push side, industry federations need to work out national and regional support for SMEs that want to invest in the production of modular retrofit with wooden elements and these federations need to convince national and regional public funding bodies to create public funding and public procurement regulations for this type of retrofit.

The organization of specific trainings on the themes related to the project (i.e. timber construction, prefabrication processes, ventilation systems, the use of RES in existing buildings) and the awareness of children on sustainability themes through activities in schools has contributed in spreading the "RENEW SCHOOL" project and this new technique of renovating buildings. The huge participation to these trainings has for sure helped in the updating of competences towards these green technologies, and the partners involved in the activities for schools have demonstrate that children have a great opportunity to modify their behavior towards the environment, the recycling methods and the use of wood as building material.

The consortium will sustain the RENEW SCHOOL project with some more effort on promoting the “Green, quixk and affordable” way of renovation with prefabricated wooden elements, at least maintaining the project website for another 5 years, working on similar national projects and carrying out regular trainings and technical visits on winning technologies.

6 References

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RENEW SCHOOL

www.renew-school.eu