The WaY TowardS Your CoOL SchOOL
A Guideline To High Performance School Renovations In Europe

SCHOOL VENT COOL

2010-2013
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Preface

This brochure is part of the work carried out in the project “SchoolVentCool - Ventilation, Cooling and Strategies for High-performance School Renovations” from September 2010 to February 2013. The project aims at promoting high performance retrofit strategies for school renovation based on prefabricated and modular design components. Off-site industrialized renovation methods enable short and smart renovation works on-site while minimizing disturbance of school operation or having the school closed for renovation. School buildings that are “fit for the future” promote energy efficiency with high indoor environmental quality and excellent educational conditions on a broad level. Further information is available on the website: www.schoolventcool.eu

The SchoolVentCool project was established in response to the ERA-NET Eracobuild joint call for research on Sustainable Renovation in 2010. The participation of each partner within the project is based on own national funding.

The partners of the SchoolVentCool project are:

- AEE - Institute for Sustainable Technologies (AEE INTEC), Consortium Leader, Austria.
- Stedelijk Onderwijs Stad Antwerpen, Belgium.
- Passiefhuis-Platform vzw (PHP), Belgium.
- Technical University of Denmark, Building Physics and Services, DTU Civil Engineering (DTU- BPS), Denmark.
- Technical University of Denmark, International Centre for Indoor Environment and Energy (DTU- ICIEE), Denmark.
- Lucerne University of Applied Sciences and Arts, Engineering & Architecture. Competence Center Typology & Planning in Architecture (CCTP), Switzerland.
- University of Applied Sciences North Western Switzerland, Institute of Energy in Buildings (FHNW), Switzerland.
Motivation

Everybody remembers the typical smell of a classroom during a wet autumn day or the heat in class during the sunny month of June. How you were drowsing away after a couple of hours and how the teacher had to open the windows so that the children could breathe again?

Many of the over 180,000 school buildings in the EU still are very poorly ventilated, with a proven negative impact on the pupils’ concentration and their learning process. When renovating school buildings, improvement of indoor air quality should be one of the main targets. Buildings across Europe have significant untapped potential for cost effective energy savings “which, if realized, would mean that in 2020 the EU will consume 11 % less final energy.” The main legislative instruments at EU level in achieving this are the: recast of the Energy Performance of Buildings Directive (EPBD) and the (proposed) Energy Efficiency Directive (EED).

The Commission’s June 2011 Energy Efficiency Directive Proposal (EED) stipulated in art. 4 that from 1 January 2014 onwards, 3% of public buildings (owned by Public Bodies) should be renovated each year. With the clear aim to save energy. Currently, the same percentage is renovated per year but in only half of the cases energy efficiency improvements are included (1,5% energy related renovation rate).

In the EC memorandum on this EED proposal schools and kindergardens are explicitly mentioned to be extra insulated, double glazed and having roofs and inefficient heating boilers replaced. According to the memo, in many cases a cost optimal renovation can bring up to 60% energy savings. The benefit could be estimated to 6 Mtoe in 2020. This would for illustration mean that the construction of 17 coal power units or about 9 000 wind turbines would be avoided. Due to the important share of public buildings (about 12% of the EU build up area), art.4 could serve as a strong driver for higher market uptake of energy efficiency in other sectors and development of the skills and knowledge required.

In a Non-Paper of the services of the European Commission on the outcome of the informal Energy Council meetings on 19/20 April 2012 (downgrading in their version the proposed EED), the scope in article 4 is reduced to only buildings owned and occupied by central government while behavioural savings as well as building renovation can be counted. As a result the estimated impact of this Article 4 is reduced from 4.2 to 0.4 Mtoe.

When going to press there is no definite decision on the level of measures the Public Bodies will have to take to meet the future definite Energy Efficiency Directive.


Currently many local governments are issuing and examining the energy performance certificates for their existing building stock. Their awareness grows on the challenges these buildings pose:

- The existing building stock has a very poor performance regarding calculated energy performance indicators.
- There seem to be significant differences between calculated figures and real consumption data - as far as monitoring data are available.
- The energy-intensive operation of existing buildings is a financial burden.
- Existing buildings must adapt to operational programs of today and the future.

As a building owner, the public sector faces the task to speed up the transformation of the building stock towards a portfolio of “nearly zero energy buildings”. A highly efficient and sustainable management of the building portfolio requires a holistic approach: This includes both the attention towards the environmental impact and the use of resources during the entire life-cycle of buildings (construction, operation, maintenance, renovation, demolition and recycling) as well as the economizing resource management.

Generally the task of managing a vast number of (existing) buildings is challenging: How can one define priorities and rank buildings for renovation? Which buildings should be renovated? And to which degree should they be renovated - insulation, replacement of the heating system…? Which buildings should only be maintained and then demolished due to their bad life-cycle perspective? The list of questions could be continued... But these questions depict the real challenge for any property manager or building owner. What then makes school building renovation to nearly zero energy building (nZEB) standards so challenging?

First of all, schools have a very different use ratio than any other large public building: 26 people in a 70 m² class room, about a 1000 people in the building but… only for about 200 days per year and with long intervals of being unused. Not the heating but the cooling of such building is the real issue. And the indoor air quality if one wants to renovate / retrofit existing buildings to nearly zero energy standards with tightly closed building envelopes.

Because it is impossible to replace all existing EU school building stock, adaptation of a large proportion of them to the new ecological standards is the only possible way to go ahead if we want to reach the EU 20-20-20 targets. But even if we would only renovate 4 % of this stock per year in a conservative way it would imply moving 7200 students...
and teachers to other schools and back after one or two years. Therefore we are looking for ways to renovate school building envelopes without having to close down schools during the renovation process.

All over Europe not only energy related but also education related developments require the adaptation of our school buildings. Comprehensive school building renovation should meet the technical, health as well as educational needs of the future. Also from the educational point of view renovation of school building stock should support advanced state-of-the-art teaching methods. While the system of education is constantly changing and the time of ex-cathedra teaching is obsolete, the buildings have stayed unchanged and do not follow modernized teaching practice. A radical change of our common practice for school renovation is urgently needed! We want our children to be educated on the highest level - therefore we have to provide an adequate and challenging learning environment to them.

High performance school renovations raise the awareness of pupils and teachers regarding new renovation and energy technologies as well as indoor environmental quality. A very important issue deals with the education based approach to change processes. School buildings and their technical equipment and operation are used as showcases for pupils and their families to influence their attitude and awareness. It offers a chance to increase the awareness for energy-efficiency and indoor environmental quality starting at schools, ending maybe at university or office buildings or similar large buildings.

From the technical point of view building renovation should aim at the high quality of the building envelope, an optimized operation of the building services and an added value for the user’s indoor comfort and educational usefulness – but it is certainly not common practice to realize these measures simultaneously and in a renovation process that does not imply closing down the school for a year or longer.

The SchoolVentCool project aims to raise both energy efficiency and indoor environmental comfort by high performance school renovation from a comprehensive and overall point of view. The promotion of effective and sustainable strategies for building renovation and the identification and analysis of solutions for ventilation and solar protection are a key issue to achieve a broader adoption in practice. Finally the main target is to achieve an environment based on energy efficiency and characterized by high indoor environmental quality and excellent educational conditions.
The SchoolVentCool methodology

Unfortunately, it is common practice in renovation projects that the architectural and structural design is developed by an architect or builder together with the building owner, but the energy concept or building service system is developed separately afterwards. At this preceded stage, necessary alterations within the building layout are hardly possible and only if the design discussion process is started again. So what happens? The building service systems (heating, ventilation, etc.) are somehow post fixed on the existing building structure. On the one hand a lack of adequate space for distribution systems is the result, on the other hand less synergies are utilized between the building structure and the building services.

Building renovation is a complex task – of course it is based on built structures and filled with techniques. But a building is made for use. A school building is there for pupils to learn in and for teachers to teach in. It has to be maintained and should be in line with our climate protection targets. So there is a broad range of aspects that have to be considered.

Nowadays the common approach in theory is to go for comprehensive and holistic renovation strategies following an “Integrated Design” approach that covers all relevant aspects. However, there are no other keywords that are used that much - but implemented rarely in practice! Why is that? “Integrated Design” is not a standard methodology. There is no general guideline that could be followed strictly. It is an attitude or mode of thinking to step back and look at the building from a holistic point of view. It is more or less the ability to work as an interdisciplinary team in order to reach a common goal.

So, a radical change in the common way of doing things is necessary. The SchoolVentCool project aims to demonstrate this new way of doing: by means of international workshops where exemplary projects practicing the “Integrated Design” process are experienced within an interdisciplinary team.

By means of selected school building case studies a customized approach for school renovation is developed as a way to demonstrate how to ‘break’ the cycle of regularly applied and accustomed procedures. To this end, a series of international workshops were arranged (Belgium, Switzerland, Denmark, Austria), in order to bring experts from all fields of expertise together to perform an “Integrated Design” process for the selected school building case studies. The result was an open interdisciplinary discussion identifying challenges and solution approaches for these specific case studies. A final analysis of strategy patterns within the solution approaches lead to the final “SchoolVentCool Methodology”. This methodology will be described in more detail later.

An “Integrated Design” approach for school renovations considers a broad scope of aspects:

- Technical and structural aspects
- Ecological aspects
- Educational and socioeconomic aspects
- Economic aspects

SchoolVentCool Workshop Graz 27th Sept. 2011: an interdisciplinary team of experts develops and discusses different strategies for renovation of exemplary demonstration projects.
School buildings are one part of a portfolio of buildings administered by local municipalities. Successful renovation of one school building cannot be approached without one basic requirement: An overview of the existing school building portfolio. The set-up of a building stock documentation system is complex but inevitable and the benefits of such a documentation system definitely outweigh the administrative work on the long run. So there is an initial demand for investment of both time and money in order to set-up and manage such a documentation system. Of course there are different levels of details on the documentation, handling, maintenance and operation and other administrative procedures. Nevertheless, every daily routine of property management needs to be documented in detail for every single building within the portfolio.

At the same time the property management aims at the development of the entire portfolio going beyond the scope of the single building. Therefore it is important to find the appropriate level of detail either for routines or for upcoming decisions.

In order to avoid investments for renovation measures in a nonselective way, it is necessary to provide the overview on the entire building portfolio in the first place. The conflict between the decision level on a portfolio perspective and the deduction of appropriate detailed measures for the single building may be solved by a procedure that approaches step-by-step: in the first place the focus is on the entire stock, then on the district, afterwards the perspective zooms to a cluster of buildings and the school ground and last at the single building.

The change of the scope from the single building to the entire portfolio avoids measures and investments in a non-selective way. Sustainable property management and development needs a profound knowledge on the existing building stock and is therefore based on a sufficient building stock documentation.
Renovation Advisory panel

It is a bad but very common habit of starting school building renovations focusing on the structural and technological perspective of one *single building*. This is indispensable - of course! But this is not appropriate for development strategies of school building portfolios. A change in the approach on the level of managing such a portfolio is necessary. Any existing school building portfolio has specific pre-settings arising from building types at any age and thereof structures that cannot be changed easily. This makes it difficult to provide one generally applicable guideline on how to proceed. The optimized solution is often a balance between different requirements, interests and preferences and is generally a compromise between several stakeholders, their interests and financial restrictions.

At this level establishing an inter-disciplinary expert team, a so-called “Renovation Advisory Panel” is necessary. The team should incorporate experts from all fields:

- Building and building technology related experts: urban planners, monument conservators, architects, HVAC and structural engineers, specialists in fire precaution, ecological aspects, ...
- Energy related experts: energy-consultants experienced in urban planning and innovative master plans.
- Experts in social and health matters: operational physicians, socio-economists, etc.
- Experts in the field of education.
- Operators and ESCos (Energy Service Companies).
- Users and user-related persons like teachers, pupils and parents.

The establishment of such a panel is reflected by the introducing keynote of Pawel Wargocki, (Ph.D., Associate Professor, ICIEE, DTU Civil Engineering, Technical University of Denmark) at the SchoolVentCool Experts Workshop in Graz on 27th September 2012:

“Invite many people with different expertise to cover all different aspects for an appropriate solution!”
Tasks of the Renovation Advisory Panel

- Provide an independent, comprehensive and interdisciplinary point of view.
- Assist property management within decision-making.
- Start, continue and keep the “Integrated Design” process alive.
- Keep the entire school building portfolio under review in order to establish a continuous improvement process.

The main task of the panel is to provide a comprehensive perspective in order to start and continue an integrated design process and to assist the property management within the decision-making process from an overall and independent perspective.

First of all the entire situation of the portfolio has to be analyzed. A methodical analysis of the existing building stock and all associated requirement profiles (building code, monument protection, fire risks, and existing standards) is inevitable for any further proceeding. All those pre-settings and constraints determine the portfolio management from the technical and structural point of view. But moreover - the main purpose of a school building has to be considered: the education of children in this school building. So the typical question at the beginning of the renovation process would be, how to renovate this one single building efficiently? – The question is correct, however, the timing is wrong! Therefore, it is essential to ask the right questions at the beginning of any school renovation.

First questions to be asked

- What do I need for the education system in future?
- To what extent can the building environment support future educational tasks?
- What is the appropriate indoor environment for our children to learn and for the teachers to teach?

Furthermore the Renovation Advisory Panel has to assist the property management within all steps of decision-making throughout the entire renovation procedure. Based on the first questions that have to be asked it continues with assistance for the definition of overall targets, objectives and specific targets through the entire planning and renovation procedures, the completion of single buildings to the operation of the building portfolio. But the advisory role must not stop at this point! It is at the same time essential to learn from first implementations and the building operation in order to adjust and refine the methodology. These experiences and knowledge have to be used as input for further procedures by feedback loops in order to obtain a continuous improvement process. So the establishment of this panel is not a single act, it has to be a rather permanent institution!
The main task of the Renovation Advisory Panel is to develop a vision for the future of the school building stock. What is the “Big Picture” that has to be gained within a certain period of time? This vision of the performance of school buildings 20-30 years ahead creates the targets that have to be designated.

These targets should address the entire building stock - all existing school buildings including the new schools that are to be built in the future. So a paradigm change to the “Big Picture” of the entire portfolio is necessary. It facilitates target-oriented development and the discussion is led on a general level for the entire portfolio instead of focusing on individual renovations.

The definition of all targets and requirements is essential: it must be possible to check their compliance after completion and during operation and to indicate who is responsible for ensuring that the targets and requirements are called for and that their compliance is fulfilled.

Basically three different options for overall targets may be identified: Climate-protection related targets (like the EU 2020 climate protection targets), building and climate protection related targets like the recast of the Energy Performance of Buildings Directive (EPBD) and the (proposed) Energy Efficiency Directive (EED) and building utilization related targets (like sufficient structures for a future education system or designated Indoor Environmental Quality).

Targets have to be defined in a clear, quantifiable and achievable way. They should address the buildings' functional usage, performance, the Indoor Environmental Quality and the outlook to the life-cycle of the buildings. These overall target-setting provides the „Big Picture“ for all school buildings within the portfolio.
The options for **climate protection targets** may comprise:

- Targets for the percentage of improvement (e.g. 80% percentage reduction of the primary energy use or greenhouse gas emissions).
- Targets to increase renewable energy supply.
- Targets to substitute greenhouse gas emissions over the life-cycle of a building.

A further possibility for target setting on a more detailed approach is to use existing (often country-specific) high performance buildings standards. For example within middle-European countries the *passive house* standard is well known. While the passive house standard initially addresses residential buildings only, it has more and more been applied also for non-residential buildings. A lot of new school buildings are built according to the passive house standard or with passive house components.

**What are overall targets?**

- Targets deduced by the *EU 2020* climate protection targets.
- Targets deduced by the **vision of a future education system**.
- Targets for building utilization and the designated *Indoor Environmental Quality*.

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*Passive House School*
De Zande, Beernem BE  
[Buro II - Kris Vandamme]

*Passive house Polytechnic School, Landeck AT*
[Architectural Office Walch]

*Minergie-P-Standard School Building, Eichmatt/Cham CH*
[Kästli & Mathys Storen AG]

*Active house Kindergarten Solhuset, Hørsholm DE*
[Sonja Geier, AEE INTEC]
The options for building utilization related targets refer to the customization of the building environment for educational purposes. The main target is a use in the best possible and sustainable way.

One key feature is the flexibility on a short term basis: Current needs for teaching have to be served - interior design and equipment of classrooms and special education rooms have to be adequate. New educational methods are based on changing activities during teaching – silent single person working alternates with teamwork and changing numbers of pupils. So rooms have to provide options to be flexible: joined together or to be separated, different classroom dimensions have to provide space for individualized instructions, for small teamwork and/or group work with a big number of pupils. Furthermore flexibility in use for other purposes than teaching can and should be made possible and promoted. The sustainability in use of a school building increases dramatically the more it is put to use. Within some European countries (for example in Belgium) all schools run over eight hours or more per day, while in others (e.g. Austria) full-time schools are still less common. In all EU countries schools are closed for many weeks per year during school holidays. Therefore many classrooms are used only some hours in the morning or about 200 days per year, which leaves the space empty for an extended period of time in which it can serve other than school purposes.

The second key feature is the flexibility on a long-term basis: with demographical changes of the population, the need for a certain type of school in a certain district may change within a few decades. But the estimated service life of buildings or components is longer than that. So massive structures and constructions that are designed more openly for slight changes require fewer efforts and less use of resources for adaptations within a building’s estimated life cycle.

Summarizing the options for building utilization related targets may comprise:

- Targets to meet short-term flexibility and to cover current user’s needs.
- Targets to meet long-term optimized usage of a building.
- Targets for a general Indoor Environmental Quality that has to be guaranteed independent of the school type or school building type.
Indoor Environmental Quality (IEQ)

The experience in many school buildings shows that indoor environment is often far from satisfactory for the users. The complaints go from the overheating of classrooms to poor indoor air quality due to insufficient ventilation as well as bad lighting and noise. It is easy to forget that the success of a school renovation may rest on its Indoor Environmental Quality (IEQ).

Indoor Environmental Quality has a broad focus: It does not only include the Indoor Air Quality (IAQ) focusing on airborne contaminants including pollutants transported from outdoors such as particles or ozone but also contaminants generated indoors by humans and their activities, emissions from building and furnishing materials, etc. and the other parameters that may influence comfort (and also health and cognitive performance) of the building users including thermal environment, adequate supply with clean and fresh (outside) air, the prevention of airborne bacteria, mold or fungi, acoustical and luminous environment. These aspects are crucial for the design of an indoor environment which does not bear risks for the occupants. Many existing standards provide some guidance how to achieve indoor environment with an adequate quality.

Examples are given below:


An important task is to define the overall targets for indoor environmental quality in school building portfolio, another one is important as well: the planning of sufficient control mechanisms to check the performance after completion and during operation. It should be mentioned that many standards and guidelines do not deal with the latter.
Priority and Potential Assessment

Particularly big school estate owners, like communities or public entities do have a broader portfolio of school buildings with different base levels. In a school building park it is more sustainable and economic on the long run to select buildings for further improvement or renovation that are more suitable than others. A broad range of aspects determine whether a school ground or school building might be adapted or renovated more viably than others. Sometimes it is probably better to demolish old school buildings and build new ones on locations much more appropriate for running a school.

At this level of the entire portfolio it is not possible to assess all buildings in detail. Renovation decisions and investments must definitely not be done in a non-selective way. Therefore the potential of the buildings within the portfolio have to be assessed and compared to the needs in order to decide on the chronological order and on the extent of renovation.

The “Potential” of a school building depicts its starting condition and is based on criteria such as:

- The building location and spatial context. This addresses the quality of the surrounding infrastructure and space.
- The flexibility of building structures on a long term perspective.

The access and distances to mobility infrastructure (public transport system) is a very important feature for future sustainable use in order to reduce individual mobility. The easier and safer children can go to school by train, busses, and tramway or eventually by walking or biking the fewer parents will bring their children to school by car. The proximity of educational or childcare facilities is advantageous due to reduced daily trip distances or shared trips. A further aspect of quality is the surrounding environment of the school building (school-ground with park or forest or recreation area nearby) as well as some relevant cultural facilities (event halls, etc.). Main issue due to the assessment of the “Potential” is to evaluate whether the quality of the surrounding area is appropriate for running a school.

The key focus of the assessment due to “Priority” is to evaluate whether the future running of the school is possible without additional measures or if its operation is already not satisfying or will be jeopardized in future.
The degree of “Priority” of a school building renovation depicts the pressure of action concerning aspects such as:

- Population development within the school district (district, municipality, etc.)
- Progress of pupil numbers
- Current state of school building structure and efficient operation (energy use)

Localization within a Potential-Priority Matrix and conclusions

To a large extent the assessment criteria depend on the country-specific framework conditions. So a Europe-wide universally valid list of school renovation criteria will not be practical. A useable proposal was modeled on the Austrian criteria catalogue for renovation to plus-energy buildings\(^3\). The list of assessment criteria for both aspects - “Potential” and “Priority” - is within the Annex of this brochure. It can be used as a template and customized to national conditions. The basic principle of this assessment is done by scoring criteria when applicable. The number of counted points is afterwards entered in Matrix with the “Priority” scoring on the y-axis and the “Potential” scoring on the x-axis. This graph is called “Potential-Priority Matrix”. So the scoring determines the position of the building in the “Potential-Priority Matrix” in order to support decision-making and portfolio development service.

The differentiated assessment - sorted by quality of the location and the priority to set measures – facilitates a better planning of further strategies for building renovation. For example: a school with an increasing number of pupils but located in a very bad location should be considered to be relocated. Maybe it is possible to switch with schools with decreasing number of pupils that are therefore too big or to reuse the building for other types or levels of education. Another option is to sell insufficient buildings and to finance a renovation or a new school building at a better location.

**Renovation type A**

School buildings with a high potential due to their location and structure and a high priority due to their needs arising from school operation and poor building structure.

**Renovation type B**

School buildings with a high potential due to their location and structure, but a low priority due to their needs arising from school operation and/or poor building structure. Further analysis could give advice whether it makes sense to keep the building and use it for other schools (that have to be resettled) or the current school operation is satisfied with the existing facility and no actions have to be set.

**Renovation type C**

School buildings with a low potential of their location and existing structure, but a high priority due to their needs arising from school operation and/or poor building structure. A closer look may give advice whether the location is not appropriate and a new school ground should be chosen or if a new building on the same location might be considered. Last option can only be realized if the space is available (besides the old building).

**Renovation type D**

Low priority and low potential of the building and/or location might be indicators to find new, more sufficient usages for the building or to sell the property.

The “Potential-Priority Matrix” is a useful tool to assess all schools within a portfolio. The position of a building marked as a dot within the matrix compared with the position of all others provides information for strategic decision-making. Portfolios may be varying - they can be generally in a very good shape or they may show generally a high need for renovation. Compared with the location of the others a target-oriented school property development planning is possible. It provides information for the order of planning and shows possible synergies or switches within the portfolio of school buildings.
Based on the ranking with the “Potential-Priority Matrix” the focus point changes. The master plans are developed for a selection of assorted school buildings (within a district or schools of the same type, etc.) out of the entire portfolio.

**Strategic master plan**

The strategic master plan aims at the development of an overall strategy for a sample of schools or buildings. A thorough analysis of available and needed spaces within the affected buildings provides a comprehensive view and may lead to more detailed recognitions. This might be done for a sample of buildings (a building cluster).

It is not significant whether buildings are locally neighbored, at the same plot or spread within the district. This strategic master plan should show the direction for a future development like switching buildings or locations, reorganization of buildings, functions or space supply for optimized operation, eventually addition of stories or annexes for individual buildings.

It must even be possible to consider the demolition or sale of buildings that are not needed. In the event of free room capacities it might be considered to sell or rent buildings or facilities in order to support the financing of future renovation measures.

Key aspect is to get an overview on the different locations and schools and facilitate a resource-efficient school location policy.

The development of a master plan is focused on a cluster of school buildings and the set-up of the most efficient renovation strategy. That comprises reorganization or switching of buildings, functions or space supply for optimized operation. Additions of stories or annexes, even to sell, to let or to demolish buildings are possible options.

- Strategic master plan
- Zoning master plan
Zoning master plan

Based on the strategic master plan that optimizes space structures and functional use of building structures from a bird’s view, it is also necessary to (re-)structure the buildings due to the interior structure – for example a zoning due to the orientation (corridors on the west-side, classrooms on the east-side), the user’s needs (comfort temperatures are higher in classrooms than they are i.e. in corridors), the difference of usage profiles and other influencing factors for interior space and room planning:

Zoning criteria

- Room (comfort) temperature
- Orientation
- Occupancy profiles (acoustics, time, utilization)
- Ventilation rates
- Air pulsion or extraction
- Fire compartimentation

School pavilions as a reaction to a changing demand on the example of Zürich

The city of Zürich expects a rising demand of school space, because of an increasing number of inhabitants. However there are uncertainties in planning (e.g. delays to construction works of residential areas). A reaction on the changing demographic demand is the construction of temporary school pavilions, which can bridge a temporary lack of school space, in case of construction works for new school buildings or renovations.

The city of Zürich owns 29 pavilions, each of which has two floors with four classrooms and two group rooms as well as toilets. One pavilion costs, around CHF 1.5 million, including access.

[CCTP, Switzerland]
The zoning is very important. It facilitates the optimization of functional processes and building services. Thus influencing the development of the exterior building envelope. The extension of glazed areas, the necessary shading and glare protection will be different regarding the needs on the inside. It is very common to regard this as a matter of design and detailed planning, but actually it is a prerequisite for an optimized and resource-efficient renovation and operation. At this stage of the renovation strategy development it is possible to switch entire functional areas from one building to another, to change orientation or to redraft development areas outside and inside the building.

Zoning is very important for the further development of the building services. Especially the kind and position of the ventilations systems is inevitably linked with the floor plan layout.

The decision-making of a centralized or decentralized solution starts at the point of zoning and re-structuring the school ground or buildings: whether there is one position to install the central system or there are a few or no suitable position.

The routing of ventilation ducts is heavily influenced by the layout of the building structure. Especially renovations are very sensitive in this regard: Alterations to adopt the built structure cause a lot of effort and constructional measures.
Categorization

Relevant key factors help to set-up workable renovation strategies. Of course furtheron a detailed design and planning has to react on the specific pre-setting of each building but first of all a structured overview with classified main categories facilitates the on-going decision-making process.

Keeping the targets of the “Big Picture” in mind, it is the classification that identifies the best renovation strategy for each building.

The classification of the building stock is done with indicators for four categories:

- Geometry of building
- Façade layout
- Façade structure
- (Monument) Protection

At the beginning a first general “strategy pattern” is identified to show the range of possible strategies. For example buildings of simple geometry and plain façade structures are more suitable for improvement measures of the thermal envelope in general and especially with prefabricated façade and roof modules. It is much more difficult to meet insulation standards at buildings with complex or highly structured façades where a strategic focus has to be laid on efficient building service system, automation or integration of renewable energy sources.

It is needless to say that buildings appear rarely that clearly. A lot of side-conditions will influence the detailed strategy in each case. Later on, detailed investigations have to elaborate and specify the renovation concept in detail.
### Façade geometry

<table>
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<tr>
<th>Façade geometry</th>
<th>Horizontal - Low</th>
<th>Horizontal - High</th>
<th>Centered</th>
<th>Vertical</th>
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<tbody>
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<td>Less than 4 floors</td>
<td>More than 4 floors</td>
<td>Up to 3-4 floors</td>
<td>More than 4 floors</td>
<td>Composition of elements from previous categories</td>
<td></td>
</tr>
<tr>
<td>Longitudinal extension</td>
<td>Longitudinal extension</td>
<td>2 or more axis horizontally</td>
<td>Vertical extension-vertical access axes (&quot;core&quot;)</td>
<td>Possibly one dominating category</td>
<td></td>
</tr>
<tr>
<td>1 main vertical access axe</td>
<td>More than 1 main vertical access axe</td>
<td>No clear preferential extension</td>
<td>Classrooms are arranged around this &quot;core&quot;</td>
<td>In any case separated treatment necessary</td>
<td></td>
</tr>
<tr>
<td>Classrooms arranged either on one or both sides of the corridor</td>
<td>Classrooms are arranged either on one or both sides of the corridor</td>
<td>Atriums surrounded by the building structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrary to horizontal lower buildings it needs differentiated attention due to fire precaution, escape routes and used materials.</td>
<td></td>
<td>In any case the vertical building category needs differentiated attention due to fire precaution, escape routes and used materials.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Strategy patterns for improvement of the thermal envelope by prefabricated façade systems *

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal - Low</td>
<td>Mostly in preference (depending on façade construction). Lower resulting loads to foundation.</td>
</tr>
<tr>
<td>Horizontal - High</td>
<td>Preferred (depending on façade construction). Building height might cause slightly higher loads on foundation.</td>
</tr>
<tr>
<td>Centered</td>
<td>Smaller module dimensions meet often existing modular structures in better way. Lower resulting loads to foundation.</td>
</tr>
<tr>
<td>Vertical</td>
<td>Special attention has to be paid: Very high loads on foundation. Fire regulations might require specific materials or measures for construction.</td>
</tr>
<tr>
<td>Mixed</td>
<td>The mixed structures lack of similar structures in general - prefabricated solutions might be viable in case of a bigger number of similar and simultaneously renovated buildings.</td>
</tr>
</tbody>
</table>

*While the first categorization targets to define the basic strategy for prefabrication concepts, the detailed key features are given by the building typology developed in the SchoolVentCool project [www.schoolventcool.eu](http://www.schoolventcool.eu)*

### Strategy patterns for integration of renewable energy sources

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large extended roof landscape or flat roofs</td>
<td>Provide possibilities for installation of PV and ST systems. Supply and distribution lines can be integrated into a sufficient (horizontal) distribution network.</td>
</tr>
<tr>
<td>Large extended roof landscape, flat roofs and façade areas</td>
<td>Provide possibilities for installation of PV and ST systems. Supply and distribution lines can be integrated into a sufficient (horizontal or vertical) distribution network.</td>
</tr>
<tr>
<td>Large extended roof landscape, flat roofs</td>
<td>Provide possibilities for installation of PV and ST systems. Often the space within the roof area is reduced (geometry and ventilation units, foul-air ducts, antenna systems, etc).</td>
</tr>
<tr>
<td>Large extended façade areas</td>
<td>Provide possibilities for installation of PV and ST systems.</td>
</tr>
</tbody>
</table>

Development of situation-related solutions might be necessary. If one category is dominating sectorial solutions might be useful.
<table>
<thead>
<tr>
<th>Strategy patterns for renewal of building services (BS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Centralized BS systems</strong></td>
</tr>
<tr>
<td>Distribution of new supply/ waste lines:</td>
</tr>
<tr>
<td>Main distribution horizontally (internal or integrated in façade e.g.: prefab shaft module within façade)</td>
</tr>
<tr>
<td>Within building (corridors - if room height sufficient, attic,..)</td>
</tr>
<tr>
<td><strong>Centralized BS systems</strong></td>
</tr>
<tr>
<td>Distribution of new supply/ waste lines:</td>
</tr>
<tr>
<td>Vertically and horizontally (internal or integrated in façade e.g.: prefab shaft module within façade)</td>
</tr>
<tr>
<td>Within building (staircases, shafts, corridors - if room height sufficient, attic,..)</td>
</tr>
<tr>
<td><strong>Decentralized or sectorial BS systems</strong></td>
</tr>
<tr>
<td>Distribution of new supply/ waste lines:</td>
</tr>
<tr>
<td>Sectorial supply solutions (inside the building or integrated in façade e.g.: prefab shaft module within façade)</td>
</tr>
<tr>
<td>Pooling of several single units to small-scaled sectorial systems (few rooms)</td>
</tr>
<tr>
<td>Decentralized units with single devices</td>
</tr>
<tr>
<td><strong>Centralized BS systems</strong></td>
</tr>
<tr>
<td>Distribution of new supply/ waste lines:</td>
</tr>
<tr>
<td>Main distribution vertically (internal or integrated in façade e.g.: prefab shaft module within façade)</td>
</tr>
<tr>
<td>Within building (staircases, shafts, ...</td>
</tr>
<tr>
<td><strong>Decentralized or sectorial BS systems but mostly situation-related solutions</strong></td>
</tr>
<tr>
<td>Distribution of new supply/ waste lines:</td>
</tr>
<tr>
<td>Situation-related solutions</td>
</tr>
</tbody>
</table>

**Horizontal - Low**

![Diagram of horizontal - low strategy](image)

**Horizontal - High**

![Diagram of horizontal - high strategy](image)

**Centered**

![Diagram of centered strategy](image)

**Vertical**

![Diagram of vertical strategy](image)

**Mixed**

![Diagram of mixed strategy](image)
### Façade layout

<table>
<thead>
<tr>
<th>Plain</th>
<th>Structured - Moderate</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Plain Façade" /></td>
<td><img src="image2.png" alt="Structured - Moderate Façade" /></td>
<td><img src="image3.png" alt="Mixed Façade" /></td>
</tr>
</tbody>
</table>

### Strategy patterns for improvement of the thermal envelope

<table>
<thead>
<tr>
<th>Centralized BS systems</th>
<th>Centralized BS systems</th>
<th>Decentralized or sectorial BS systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to manage improvement of thermal envelope - options:</td>
<td>Improvement of thermal envelope feasible - options:</td>
<td>Improvement of thermal envelope labor-intensive - options:</td>
</tr>
<tr>
<td>Prefabricated façade solutions*</td>
<td>(Partly) Prefabricated façade solutions*</td>
<td>In-situ assembled façade solutions (ETICS, rear-ventilated)</td>
</tr>
<tr>
<td>Partly prefab solution</td>
<td>In-situ assembled façade solutions (ETICS, rear-ventilated)</td>
<td></td>
</tr>
<tr>
<td>In-situ assembled façade solutions (ETICS or rear-ventilated façade systems)</td>
<td>Thermal bridges are mostly and largely feasible to eliminate.</td>
<td>A lot of thermal bridges will be difficult to be eliminated feasible or anyway.</td>
</tr>
<tr>
<td>Thermal bridges are mostly and largely easy to eliminate.</td>
<td>Design, foundation method, system, distribution of ventilation and mounting process will be affected by existing façade structure (massive, element, skeleton)</td>
<td>Design, range and system will be affected by the existing façade structure. Distribution of ventilation will be preferentially inside the building.</td>
</tr>
<tr>
<td>Design, foundation method, system, distribution of ventilation and mounting process will be affected by existing façade structure (massive, element, skeleton)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*While the first categorization targets to define the basic strategy for prefabrication concepts, the detailed key features are given by the building typology developed in the SchoolVentCool project (see www.schoolventcool.eu)*
**Facade structure**

<table>
<thead>
<tr>
<th>Punctuated facade</th>
<th>Skeleton facade</th>
<th>Element façade</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings with massive structures and perforated with openings like windows and doors:</td>
<td>Buildings with skeleton structures (reinforced concrete/ steel) and non-load-bearing infill (parapet and lintel)</td>
<td>Buildings with skeleton structures (reinforced concrete/ steel) covered with non-load-bearing façade elements. Building structure is not visible on the outside and entirely covered on the outside. Rear ventilated façade</td>
<td>Buildings with already existing damages of the supporting structures - caused by inconsiderate renovation measures, new unexpected loads or too small dimensioning right from the initial structure. Very good indicators are typical cracks within load bearing walls.</td>
</tr>
<tr>
<td>Monolithic walls with different brick material (full or hollow bricks) or concrete blocks, etc.</td>
<td>Skeleton filled with masonry or other compact materials</td>
<td>Rear ventilated façade</td>
<td>Non-rear-ventilated facade</td>
</tr>
<tr>
<td>Monolithic walls with cellular concrete or lightweight concrete</td>
<td>Skeleton filled with less compact fillings like thin masonry or wood-based plate materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavity walls (outside with facing bricks or plastered wall)</td>
<td>Plate construction type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctuated facade</td>
<td>Skeleton facade</td>
<td>Element façade</td>
<td>Deficient</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>---------------</td>
<td>-----------</td>
</tr>
<tr>
<td><img src="image1" alt="Punctuated facade" /></td>
<td><img src="image2" alt="Skeleton facade" /></td>
<td><img src="image3" alt="Element façade" /></td>
<td><img src="image4" alt="Deficient" /></td>
</tr>
</tbody>
</table>

### General strategy patterns for renovation

#### Focus on:
- Exterior insulation as additional layer (prefabricated or in-situ)
- Potential of thermal mass (heating, cooling, night ventilation)
- Low temperature heating systems supplied by solar thermal systems

#### Focus on:
- Exterior components taking advantage of good anchorage ground preferable as additional layer on the outside (to enclose envelope entirely and eliminate thermal bridges)
- Proof exchange of non-load bearing infill of parapet and lintel (attention to thermal bridges)
- Consider integration single ventilation devices within parapet or lintel
- Potential of thermal mass (heating, cooling, night ventilation)

#### Focus on:
- Exchange of exterior façade elements to prefabricated modules or small-scale on-site mounted claddings
- Consider integration of single ventilation devices within elements
- Consider integration of shafts within new envelope as vertical elements for an easy renewal of supply lines (insulation layer implemented on the outside of the shaft)
- Efficient shading to avoid thermal loads during day

#### Focus on:
- Careful check prior to renovation due to life-cycle costs and current building shape
- Outlook on a long-term basis for the building and the school-operation
- Consider switch to other available buildings

#### Check compressive and tensile load bearing capacity of supporting walls. If existing structures are not sufficient enough for loads from new façade a load-distributing substructure or additional foundation might be necessary.

#### Check compressive and tensile load bearing capacity of supporting structures. If existing structures are not sufficient enough for loads from new façade an additional foundation might be necessary.

#### Check compressive and tensile load bearing capacity of supporting structure. If existing structures are not sufficient enough for loads from new elements an additional foundation might be necessary.

#### Compressive and tensile load bearing capacities mostly exhausted or exceeded. Reinforcement of existing structure necessary.
<table>
<thead>
<tr>
<th>Protected Buildings</th>
<th>Partly Protected Buildings</th>
<th>Non-Protected Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings that are entirely protected – any measures outside and inside the building need permission of authorities that are in charge of monument protection.</td>
<td>Buildings that are only partly protected - mostly the façade (facing the street) is preserved and alterations need the permission of authorities in charge of monument protection;</td>
<td>Basically all buildings are not burdened by monument restriction. But in case of cavity walls or walls with facing brick it might be possible that even non-protected buildings are constrained due to alterations of their appearance.</td>
</tr>
<tr>
<td>Further requirements may arise for specific city areas (for examples with protected roof landscape) or restrictions addressing historic windows, etc.</td>
<td>Other requirements may arise for specific city areas (for examples with protected roof landscape) or restrictions addressing historic windows, etc.</td>
<td>Further restrictions aside from monument protection may be caused by fire safety regulations, building codes, etc.</td>
</tr>
<tr>
<td>Protected Buildings</td>
<td>Partly Protected Buildings</td>
<td>Non-Protected Buildings</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td><img src="image1" alt="Protected Building" /></td>
<td><img src="image2" alt="Partly Protected Building" /></td>
<td><img src="image3" alt="Non-Protected Building" /></td>
</tr>
</tbody>
</table>

### General strategy patterns for renovation

- **Use potential of thermal mass (heating, cooling, night ventilation)**
- **Careful renovation of historic windows**
- **Low temperature heating systems supplied by renewable energy sources or adequate district heating**
- **Compensate impossible wall insulation with possible insulation of roof top ceilings or ground floors**
- **Supply with district heating based on renewable energy sources or utilization from neighboured facilities**
- **Utilization of geothermal energy**
- **Organizational measures**

- **Use potential of thermal mass (heating, cooling, night ventilation)**
- **Careful renovation of historic windows**
- **Low temperature heating systems supplied by renewable energy sources or adequate district heating**
- **Moderate interior insulation or partly exterior insulation (inner courtyards, etc.)**
- **Compensate impossible wall insulation with possible insulation of roof top ceilings or ground floors**
- **Improved use of renewable energy sources**
- **Utilization of geothermal energy**
- **Organizational measures**

- **Use potential of all possible options (envelope improvement including windows and all thermal bridges, renewal of building service systems, generation of renewable energy systems on-site, organizational measures) to the maximum**
- **Massive interventions inside and outside to reorganize the building layout to the optimum**
- **Significant measures to optimize envelope (new glazings, closing insufficient glazings)**
- **Options of overproduction of energy in order to supply neighboured facilities or buildings.**
Specific requirements

The overall targets and strategic framework for the portfolio have permission of authorities been set up. Now the focus is on the single building. Having the “Big Picture” in mind it is now easy to filter out from the overall targets down to specific requirements of the single building.

What are specific requirements?

- Specific limits for the heating and cooling demand in order to reach 80% reduction of the primary energy use or the greenhouse gas emissions.
- Definition of the U-values of relevant building components or windows and glazings and the airtightness of the envelope.
- Quota of renewable energy supply and substitution of fossil fuels.
- Mandatory life-cycle analysis aiming at the substitution of resources for renovation within the defined design life.
- Energy saving pumps and ventilators (limitations on maximum power consumption).
- Target for daylight coefficient (min. 2%).
- Installation of energy saving lights
- Mandatory lighting concept including simulations and analysis of different variants in order to reduce power consumption and optimize daylight use.

Now the strategy for the specific school-building with its own environment and conditions has to be developed. Having the vision of the „Big Picture“ for the entire building stock very clearly in mind it is easy to deduct the specific targets for single buildings. So the overall targets have to be brought down and interpreted: What does it mean for that specific single building?
Further requirements may arise due to the schedule for renovation works. It has to be balanced between the extension of work and the available time frame. Depending on the necessity to continue school operation it might be necessary to do all the work during holidays and perform customized construction procedures which do not disturb teaching during school time. This meets the upcoming approach of stepwise building renovation. Of course it is a matter of increased planning and organizational effort but on the other hand the school has not to be relocated or renovation measures have not to be shortened due to a lack of time.

At the same time it is necessary to have the results of a thorough investigation of the existing building present:

- The \textit{structural analysis} of the building. Including all drawings, photo documentation and an inspection due to existing building damages or weak points.
- Establishment of a “\textit{project cloud}”. This cloud is a result of a serious project environment analysis of all involved users and stakeholders, their profiles, needs and interests. On the one hand this comprehensive overview enables decision-making on short and long-term perspectives, on the other hand it provides the common thread for sufficient integration of all persons involved throughout the entire process.
- A \textit{first energy analysis} based on calculations and the actual consumption data concerning heat and electricity consumption split up among the different users (heat, DHW, cooling, auxiliary, lighting, operation).
- A \textit{serious and profound questionnaire} of users on existing damages, malfunctions, constraints.

\textbf{The thorough investigation is vital!}

- Structural analysis
- Project environmental analysis
- Energy analysis
- Questionnaire
The planning of specific renovation measures is now a first step towards a technology and structure related perspective on the renovation of a school building.

The perspective on the single building addresses each specific school building with all its pre-settings and local conditions. Even though a building documentation is available, a detailed functional and a structural analysis has to be conducted and – preferentially combined with a life-cycle analysis of the existing structure.

Improvement of thermal envelope

All discussions about a new building envelope have strong affiliation to the architectural quality. Even in cases where the building is not protected, very often some significant distinguishing marks might be kept for the future. For example traditional brick walls are a typical façade structure in Belgium, Denmark or Great Britain, etc. A special attention to such typical building characteristics should be an integrative part of any renovation concept even though the building is not protected.

Hence a lot of buildings, especially historic buildings, have to face the situation that an entire enclosure of the buildings envelope is not possible. Therefore compensating measures are an integrative part of the concept. The range of options for thermal improvement measures has to go beyond the sole insulation of the envelope to a broader scope of conservation and efficiency measures such as the initial zoning of rooms and spaces within the building, the usage of thermal mass, the improvement or replacement of windows, doors and glazing.

Basically measures can be separated into: „Passive“ ones, like the improvement of the thermal envelope, efficient shading or optimized used of daylight, „active“ ones that include efficient mechanical ventilation or heating systems, lighting control or others. Besides constructional or technical options organizational measures are an option too - they have to be planned in strong cooperation with all building related measures and the intended users. But anyhow the point is not to use the best measure, it has to be the most suitable measure!
Exterior insulation

Although the cooling need is a big issue for schools an exterior insulation improves the thermal performance and keeps heat storage mass inside. It is easy to apply and facilitates elimination of thermal bridges. Solutions range from a mere enclosure to an extension of rooms by a new thermal envelope.

Interior insulation

Interior insulation is mainly used for historic buildings, but it is more difficult to manage the building physical challenges there. Interior insulation asks for careful and detailed planning and thorough supervision of workmanship during construction works. Only consequently implemented insulation and vapor barrier layers enable a proper realization without predetermined future sneaky building damages.

Prefabricated envelope solutions

The implementation of prefabricated elements facilitates short construction or mounting times on-site and is therefore highly appropriate for school renovations during the summer holidays (for example). Further on it is more or less weather independent and workmanship is easier to be controlled under the conditions of a fabrication hall. This solution excludes monument protected building parts but is especially suitable for required façade changes (e.g. classrooms that will be turned into laboratories with less or no daylight requirements). Prefabrication methods targeted for school buildings are developed within the SchoolVentCool project (from autumn 2012 on www.schoolventcool.eu).

Thermal optimized windows and doors

The general impact of thermal optimized windows, doors and other transparent building components (with low U-value) are reduced heat transmission losses. Further windows and doors with lower solar energy transmission (g-value) reduce the energy input from glazing during summer. Beside the U-value and g-value of windows and doors it is further important on how the window is mounted and installed.

Recently the approach of stepwise renovation is considered more often. Thereby one of the first measures is the window-exchange whereas windows are fitted tight into the existing opening. Then, a year or so afterwards the exterior insulation of the walls follow but no sufficient space for the insulation of the reveal is left and if only a too small insulation layer is brought up and a thermal bridge is created that might cause damages due to condensation. Therefore special attention has to be paid to find appropriate solutions for the interfaces between different renovation steps.
Ventilation systems

Ventilation in classrooms may in general include natural and mechanical ventilation systems, as well as hybrid (mixed-mode) systems being the combination of the two. Furthermore ventilation systems can be characterized as central and local systems. Natural ventilation systems comprise the solutions in which differences in pressure caused by wind or differences between indoor and outdoor temperatures are used to air the classrooms.

In a specific school location the possibilities have to be deducted from a number of considerations on both internal and external issues.

School ventilation concepts and systems

- Natural ventilation concepts
- Mechanical ventilation system (centralized or decentralized)
- Hybrid ventilation systems (mixed-mode)
Generally mechanical ventilation systems consist of only an exhaust ventilation and an inlet mechanical system (seldom) and fully balanced systems with the supply and exhaust. Exhaust ventilation is usually realized via restrooms. In balanced systems the air supplied to classrooms is centrally conditioned and often the heat from the exhausted air is recovered.

Yet within existing schools natural ventilation concepts are the rule rather than the exception. It is basically achieved by an operable window (manually or automatically operable). Room air supply through simple façade openings like windows without preheating causes draught. Therefore the location of the openings must allow the air jet to mix and subside before it reaches the occupants. Consideration should be given to pre-heating systems, e.g. radiators, heat coils or simply limit the operation of natural ventilation to the summer period. The latter requires a mechanical system during winter, effectively creating a mixed ventilation system. The main challenge is the guarantee of sufficient indoor air quality during school time.

Quantitative requirements for school ventilation concepts

The EN 15251 provides in case of missing national criteria for design and dimensioning of systems recommended design values for three different categories:

- **Category I** - High level of expectation, recommended for spaces occupied by very sensitive and fragile persons (kindergarten, hospitals, etc.)
- **Category II** - Normal level of expectation. To be used for new buildings and renovation.
- **Category III** - An acceptable and moderate level of expectation. May be used for existing buildings.

Qualitative requirements for school ventilation concepts

- The separation between ventilation systems and heating/cooling systems
- The use of radiant heating instead of air-heating
- Windows those are free to open
- Indoor temperature adjustable by users per room

Hybrid systems have two components: natural and mechanical system. The hybrid system in some periods use natural forces to air classrooms and when the conditions do not allow sufficient ventilation the mechanical system is turned. The best example would be the system with automatically operable windows which are supported by the exhaust fan turned on when the ventilation is insufficient. The systems can be centralized and localized, the former usually providing ventilation air for the entire building or building zone the latter being the local solution; natural ventilation by operable windows is a local ventilation solution.

So the mixed systems that employ natural and mechanical ventilation offer individual advantages of separate systems. With fans indoor air quality during school-time is guaranteed while passive cooling concepts like night ventilation or cross ventilation during warmer periods are additionally possible. Such combinations enable tackling of internal heat surplus with more “robust” systems. They do not require though the construction and maintenance costs of two separate systems.
Natural ventilation systems comprise also stack ventilation (bricked shafts providing airing of the room). This ventilation system was common in school buildings of the former days.

For any type of system the quality of outdoor air is essential. It can be much better controlled in mechanical systems where special filters can be installed to remove outdoor contaminants especially particles and ozone. This is more difficult to achieve in natural systems, though there are numerous efforts at present to find solutions allowing the removal of outdoor pollutants. In these systems especially when airing is achieved by operable windows outdoor noise plays an important role and can be the factor limiting the use of windows. Also large differences between indoor and outdoor temperatures, particularly in winter periods can limit the opening of windows; in this way the classroom occupants can avoid cold drafts. Too high air velocities and drafts, as well as noise can be a problem in the mechanical system, too, unless properly designed and balanced. Mechanical systems, either local or central require regular maintenance, e.g. change of filters, service of the equipment etc. Lack of regular maintenance may lead not only to improper operation of the system; the system can also become an additional pollution source (e.g. dirty filter, dirt on duct, etc.).

The challenge of installation within existing school buildings

Very wide-spread floor layouts with less numbers of floors make vertical duct distribution not viable. As a rule of thumb horizontal duct lengths of maximum 25 m are preferred. A school layout with a central corridor facilitates an internal horizontal distribution – the corridor acts as a horizontal supply line designed as a “backbone” above the suspended ceiling of the corridor. With the optimum location of the main duct, preferably a central location, the main duct can supply approx. 50 m of building.
Which system is the best?

The selection of the system will depend on school location, urban, rural, close to roads with intensive traffic, configuration (multi-storey or one-storey building, access to classrooms, construction, fire protection requirements, etc.) and many other factors. There does not exist one solution that fits all. The most important is to pay attention to factors mentioned above: outdoor air pollution, drafts and noise, as well as maintenance. Possibility of energy recovery will always be the advantage but should not be the only factor that needs to be considered. Climate conditions can have an important impact on the ventilation solution; schools located in cold climates may require mechanical ventilation and these located in warmer climates may opt the natural systems. Mixed-mode hybrid systems seem to form a most universal ventilation solution allowing utilization of the best features of mechanical and natural systems. They allow achieving ventilation requirements independent from the outdoor conditions and they use natural forces whenever possible.

In school locations in urban areas the level of noise and air pollution are issues which would make natural ventilation by facade openings unconceivable. On the other hand favorable wind conditions can be exploited for cross ventilation between facades. For schools with several floors the stack effect (buoyancy) can be exploited for controlled natural ventilation. In order to be effective one main common room collects the extract air from several connected rooms and exhausts it through the shafts. The air passes from the outside through the facade openings, then to a high ceiled room before being exhausted some meters above the highest intake opening. Examples of high main rooms are atriums, hallways or staircases and the openings are controlled via building management system. However, to use safety passage ways for ventilation air is not always in compliance with local fire regulations. The stability of the air supply can be improved with assisting fans used in conjunction.
Regular maintenance is crucial for any mechanical ventilation system. Irregular replacement of filters and checkups compromises energy, air quality and life span. Units in a decentralized spot carry a higher embedded risk of irregular service and replacements of filters and parts.

Due to fire-precaution the supply of each classroom has to be compartmentalized from the central supply line. Decentralized units of mechanical ventilation do not violate the fire regulation for compartmentalization. They are placed in each classroom as all-in-one combo boxes and are a sound alternative to central systems when focus are on construction and energy costs.

Organizational measures

Every renovation of school buildings concerns basically technical and organizational issues. But experiences in Austria where school renovations have been socially-scientifically supervised, showed the importance of continuous integration of the users (respectively pupils, teachers and the caretaker). The future operation of the school buildings depends on how their needs are met and how especially the caretaker is able to handle all building services. The users’ understanding of the use of the building after renovation is very important for a comprehensive performance of the process.

It is very important to give everyone the appropriate information so that the future building and all its services will support the running of the school at its best. In order to reach energy efficiency in operation it is necessary to include user’s interests and needs.

*Information and communication* can decrease (indirectly) final energy use of the school when users are well-informed about technical equipment, services and maintenance. This helps to optimize building operation. Information and communication with users should be passed on regularly before, during and after renovation. Continuous feedback and eventually target-oriented energy and indoor environmental quality monitoring ensures energy efficiency on a long-term perspective.

High awareness of users changes the traditional behavior in dealing with new ventilation and heating systems or current devices in schools contribute to the public attitude of energy saving also within their private households. So the term “*the learning is not just for school, but for life*” gets an additional meaning.
Organizational measures for the start in brief

- Understandable and practice-oriented documentation and maintenance instructions for caretakers.
- Serious initial instruction operation targeted to caretakers and teachers.
- Assistance for first year of operation targeted to caretakers.

Organizational measures for operation in general

- Coordination of utilization schedule with building control.
- Monitoring of consumption data with periodically evaluation and following fine-tuning of building control systems.
- Ongoing awareness raising of for teachers and pupils like periodical information on monitoring results.
- Periodical questionnaires of teachers and pupils and following apparent re-actions.

The evaluation of monitoring data of the first year resulted in organizational measures like adaptations of the switching time of the heat pump, ventilation system and circuit lines, alterations of the switching moment of the pre-heaters of the ventilation system and the correction of malfunctions of top lights.

The chart above shows significant reduction of energy consumption for ventilation, wall heating system and circuit pumps as a result of this fine-tuning during the first year of operation.

[Monitoring Passive house Kindergarten, Deutsch Wagram, AEE INTEC 2012]
Best Practice

High performance renovation and improved Indoor Environmental Quality are very often used keywords. It is obvious that a lot of building-related conditions influence the quality of learning and teaching. A lot of such high performance renovations have already been realized within Europe, but why is it so difficult to find good examples of successful school renovations? Why do school building pilots keep being pilots projects without moving towards volume market in school renovation? Why do a lot of decision makers hesitate to invest in high performance school renovations?

The advantages are apparent: improved indoor environment quality optimizes the building operation and decreases operating costs. Of course any renovation is a challenge, there is no safe formula for success. The Best Practice examples demonstrate that high performance school renovation does pay off! But it is also clear that every successful example confirms the necessary puzzle pieces of “Integrated Design”.

Look - it can be done, it is possible and feasible! The best way to prove theories is to show that they had been realized already. Although every project has its own specific approach – the pattern of the strategy and the subsequent success is always the same. So every best practice example provides the chance to learn and the motivation to keep it up.

An inner atrium, a sophisticated daylight color design concept and brightens the core of the school building in Schwanenstadt (AT) after renovation. [PAUAT]

A small demolition inside the school building in Zirbitzkogel, Grebenzen (AT) for a maximum effect: a new entrance hall and access full with light. [ARCH+MORE/ Blende 16]

A new façade with beech wood gives the interior courtyard a new atmosphere. School building in Schwanenstadt (AT) [PAUAT]
Case 1 - Master Planning for School Building Stock, an Antwerp Experience

Location: Antwerp, Flanders (Belgium)
Started: 2009
Responsible departments: Cabinet for education, work & economy
School-building portfolio: 250 Schools, 50000 Pupils
Total gross floor area: 243571 m² treated new build & renovation
Investment: 432.3 Mio Euro between 2011 & 2025

With its Strategic Master Plan (SMP), Stedelijk Onderwijs Antwerpen wants to improve its learning environments for over 50.000 pupils and 6.000 staff in more than 250 school buildings, because it believes that well designed learning environments will inspire better learning outcomes.

The SMP also has to support the city of Antwerp’s vision on sustainability. Sustainable education in sustainable premises will help the city to meet and even exceed the EU 2020 educational and ecological targets. High quality learning environments, choice of state of the art technical solutions, preservation of heritage values and a cohesive, inclusive vision on campuses were all crucial ingredients considered to achieve this vision.

Creating a Strategic Master Plan for a large school building stock with many different stakeholders is no sinecure. Once the strategic planning has started, there is no way back. Reaching each milestone means decisions that can only be changed or reversed at great cost. And along the winding path to the SMP, there are many stakeholders with ample reasons and desires to change parts of the SMP in favour of their own plans and aspirations. Lots of checks and balances have to be met, not only didactical and pedagogical, but also demographical, ecological, financial and not in the least political ones. There is a lot of diplomacy needed to find ways out of such bottlenecks. But if some key issues have been cleared beforehand, such as sponsorship, procedures, hierarchy in decision making, pre-agreed milestones, timing and clear targets to reach; creating a SMP will not only give the organisation a firm basis for future investments, it will also force all stakeholders to think strategically about their business: creating a better learning environment for pupils and teachers alike.

Between 2010 and 2026
The City of Antwerp will need schools for at least 30.000 extra pupils in compulsory education!
Why a strategic master plan?

The 2010 - 2025 Strategic Master Plan (SMP) for Stedelijk Onderwijs Antwerpen (SO) building stock capitalizes on the autonomous municipal education companies’ existing assets and provides a development framework addressing the education networks’ vision, needs and aspirations.

Phase 1: Establishing political sponsorship, overall goals and procedures

The cabinet of the vice-mayor for education, work and economy created a first separate document “towards a master plan for municipal education”. It was discussed within the management board and later approved by the board of trustees, the city college and the city council. The document defined the overall strategies and procedures and the political sponsorship of the city council and especially the vice-mayor for education.

► Milepole 1: decision on a political sponsorship, overall goals and procedures

Phase 2: Defining a blueprint for sustainable school buildings

A separate document defined a “blueprint for sustainable school buildings”. It was prepared by AG Vespa, the city autonomous company for investment in real estate and city projects, in co-operation with principals, teachers, maintenance people, city architects and planners, the city building master, the city environmental agency, ...

► Milepole 2: acceptance by the city college of blueprint for sustainable school buildings

Example of city map showing % of pupils in secondary vocational education in each district [Stad Antwerpen]
Phase 3: Creation of the actual master plan v.1

3.1 Collection of data and knowledge on the building stock

A Master plan team was established to make correct listings of the building stock based on cadastral numbers (names of schools tend to change over the years, cadastral numbers do not) with for each building a determination of its typology, the number of m² of the different surfaces (classrooms, circulation, sports facilities etc.). Assessment of existing energy consumption and detailed quality assessment of the buildings was outsourced, using the NEN 2658 building assessment tool (Programmes of requirements for buildings and associated project procedure, Dutch Standards Institution, 1993) developed by Technical University Delft (NL).

► Milepole 3: All possible data on building stock collected and (double) checked

Data on the demographic changes and need for building capacity | Since 2005 the city statistical service has been conducting a comprehensive survey on demographic changes in the city neighbourhoods using predictive software to assess future needs. Every year the central pupils’ registration confirmed these needs but also calculates on a yearly basis the existing capacity in all education networks in Antwerp.

► Milepole 4: Demographic data collected & capacity discussed with all school networks

Data and vision on new didactical /pedagogical needs | Decisions were reached about ICT, inclusion, reorganising grades, vocational education, “open schools”. Stedelijk Onderwijs chose to create campuses instead of independent dispersed schools, based on the choice for mobility and social inclusion.

Mobility according to the “S.T.O.P principle” which first promotes walking, then biking and public transport and discourages the use of private cars for inner city mobility. Because of their limited mobility it was decided to create children and youth campuses in each neighbourhood: nursery, kindergarten, primary and first two grades of secondary education. By extending the stay on the same campus, the selection of a type of secondary education can be moved from the age of 12 to 14. This will enable teachers, parents and pupils to make more well-advised choices for further education, preventing truancy, drop-out and unqualified school leaving.

For pupils with higher mobility, existing secondary and adult schools would be reorganized on thematic campuses (general, technical, vocational) and art campuses in each district. Preferably on the cross roads of circular and radial public transport lines (train, metro, trams, buses) to create a better mix of pupils from the inner city (mostly lower socio-economic level) and pupils from (wealthier) suburbia.

► Milepole 5: Clear decisions reached on didactical & pedagogical choices for the future

On new building techniques to reach Passive House (PH) or nZEB standards | As of 2009 the city of Antwerp decided to build only PH schools. Passive House Platform was asked to give support to create newly built PH schools. But as “newly built” alone cannot make reaching the EU targets possible, renovation to PH or nZEB standards of a large part of the building stock is necessary. Only industrialized modular retrofit will make it possible to achieve this fast enough. And as a partner in the SchoolVentCool project, SO hopes to improve simultaneously the indoor air quality with better ventilation and cooling.
3.2: pendulum negotiations

One “editor” was commissioned to co-ordinate the SMP process, sponsored by the vice-mayor and the board. A hierarchy of targets was decided.

► Milepole 6: Commission co-ordinating editor / project manager & hierarchy of targets

All existing master plans per division were collected and individual meetings of the editor with all division managers gave a clear picture about their aspirations and their targets. This led to mini-master plans and to series of “dominoes” for several sites. A domino project involves consecutive decisions wherein several buildings and schools are concerned finally resulting in the new campuses.

► Milepole 7: First overall draft of the strategic master plan

3.3: Final negotiations

Each division manager presented his part of the SMP in plenary meetings to all other managers, the vice mayor, the general manager and the editor. “Give and take” negotiations create a balance between investment in capacity, rational energy use and pedagogical needs. The editor wrote a second version of a draft master plan, listing all decisions and short-listing all still undecided issues. Final debates presided by the vice-mayor and general manager led to final decisions on all issues.

Examples of new built Passive House Schools in the City of Antwerp [Planners, Compagnie-O architecten]
Phase 4: writing & deciding the SMP in its first definite version

The editor used all this basic input to finalize the first version of the SMP. Approximately 200 formulas and 18,000 automated calculations were needed to create interrelated spreadsheet files, adaptable for future versions. The costs/ m² were calculated for each type of investment and related to the according m² per building. A priority list of over 300 different actions and dominoes for execution in 168 lines and 99 columns between 2011 and 2025 shows an investment of over 442 Mio Euros. The matrix includes the planned start, duration and completion of all individual construction sites and actions to rationalize energy use, the timing in communication, budgets and co-financing available and needed per action and per year. It also includes the overall budgets assigned and needed, cash flow expectancy, needs for external co-financing and possible financial constructions.

► Milepole 8: Masterplan v.1 agreed by the management board, board of trustees and the city college

The whole procedure took well over a year...

... and then the job to put all this in to realization only just begins!
Case 2 - Passive house Renovation Nature Park School Zirbitzkogel Grebenzen

Location: Neumarkt, Styria (Austria)
Year of construction: 1978
Year of renovation: 2009 - 2011 (2 construction stages)
Building owner: Municipality of Neumarkt
Architect: Gerhard Kopeinig, ARCH+MORE ZT

The success story of the renovation started with an open project development that integrated the intended users right from the beginning and aimed at enhancing the incorporation of the school into the region. Besides the secondary school the buildings also host the public music school, rooms for clubs and event rooms for the municipality. On the other hand a strong focus was set on wood as regional construction material.

A major part of the building complex was renovated with prefabricated wooden modules that were cladded afterwards with a wood slat façade. The installation of a centralized ventilation system with 80 % heat recovery, external venetian blinds and a very elaborate system for night ventilation were designed in order to guarantee a high indoor environmental quality.

Heating demand: 160 before, 14 after renovation [kWh/m².a]
Gross floor area (GFA): 3526 m² before and after renovation
Investment/m² GFA: 950 € - 1250 € - 1450 € per m² (excl. VAT) depending on the differences with the existing building parts
Ground floor plan and construction details
[ARCH+MORE/ Blende 16]

School entrance after renovation
[ARCH+MORE/ Blende 16]
The school was retrofitted in an inhabited status mainly during holidays 2011. The old steel-glass façade was demolished and replaced by TES EnergyFacade, a prefabricated timber system. The timber frame elements were directly mounted on top of the existing structure with a dimension matching the grid (2.35 m) of the load bearing steel columns at a building height of 7.9 meters. Due to the shape of the linear windows, the glazing was mounted at the same time, leaving the interior protected to the outside at any time.

A steel-glass pyramid over the main staircase was replaced by a prefabricated timber roof construction. The 10 x 10 meter wide hat was mounted as one single piece.

The project has proven the feasibility of applying large façade elements at a maximum level of prefabrication.

Heating demand
220 before, 70 after renovation [kWh/m².a]

Gross floor area (GFA)
2877 m² before and after renovation

Investment/m² GFA
ca. 240 € (excl. VAT)
Ground floor plan and construction detail
[Lattke Architekten]

School building after renovation
[Lattke Architekten]
Summary and Conclusions

Any school renovation should be planned for a long term multi-purpose use: First of all a basic knowledge on the existing building stock is necessary and the overall main targets have to be defined. These are targets arising from future-oriented education systems and energy- and climate-related aspects.

The integration of an interdisciplinary expert team (“Renovation Advisory Panel”) and an overall master plan provides a basis for further decision-making and action lists. Target setting from a bird’s view and the identification of detailed requirements is a step that is actually underestimated and has to be recognized as an important issue for any decision. This approach has to integrate all stakeholders involved comprising educational, constructional and operational aspects – and in case of historic buildings the monuments office should be integrated from the very beginning. The participation of users as a part of the expert team is important – but the short-term needs have to be balanced carefully with the long-term perspective of the building.

A further requirement is the balance between the overall strategy and on the specific pre-settings and conditions on-site. Not any feasible solution for a building is transferable to all other buildings. Easily applicable systems are not always the right answers – the simplification of the solution (for example mixed ventilation systems) enhances complexity during planning but possibly provide more sustainable systems for building operation.

Within the discussion panels in the SchoolVentCool project it was recognized that the situation in all participating countries is very similar. The task to get school buildings “Fit for the Future” is a challenge and needs joint efforts within Europe. Hence our call for a future intensive exchange of knowledge and experiences on transnational level to facilitate the development of optimized renovation strategies for our school buildings.
**Annex - Proposed Criteria List**

Assessment of the “Potential” of school buildings.

<table>
<thead>
<tr>
<th>Reachability with public transport system</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance to the next station or stop (train/bus/tramway)</strong></td>
<td></td>
</tr>
<tr>
<td>≤ 100 m</td>
<td>10</td>
</tr>
<tr>
<td>≤ 300 m</td>
<td>6</td>
</tr>
<tr>
<td>≤ 500 m</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 500 m</td>
<td>0</td>
</tr>
<tr>
<td><strong>Public transport service during school-days (7:00 - 18:00) provided every</strong></td>
<td></td>
</tr>
<tr>
<td>≤ 15 min.</td>
<td>10</td>
</tr>
<tr>
<td>≤ 30 min.</td>
<td>6</td>
</tr>
<tr>
<td>≤ 60 min.</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 60 min.</td>
<td>0</td>
</tr>
<tr>
<td><strong>Travelling time with public transport system to the next center (city)</strong></td>
<td></td>
</tr>
<tr>
<td>≤ 10 min.</td>
<td>10</td>
</tr>
<tr>
<td>≤ 20 min.</td>
<td>6</td>
</tr>
<tr>
<td>≤ 30 min.</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 30 min.</td>
<td>0</td>
</tr>
<tr>
<td><strong>Distance to bike path (network)</strong></td>
<td></td>
</tr>
<tr>
<td>≤ 100 m</td>
<td>10</td>
</tr>
<tr>
<td>≤ 250 m</td>
<td>6</td>
</tr>
<tr>
<td>≤ 500 m</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 500 m</td>
<td>0</td>
</tr>
</tbody>
</table>

**Surrounding infrastructure and other facilities**

| **Distance to next child welfare facility** | |
| ≤ 500 m | 6 |
| ≤ 1,000 m | 2 |
| > 1,000 m | 0 |

| **Distance to other compulsory, secondary or high schools** | |
| ≤ 500 m | 6 |
| ≤ 1,000 m | 2 |
| > 1,000 m | 0 |

| **Distance to urban district or local center (with public administrative facilities)** | |
| ≤ 500 m | 4 |
| ≤ 1,000 m | 2 |
| > 1,000 m | 0 |

<p>| <strong>Distance to commercial facilities (daily needs)</strong> | |
| ≤ 500 m | 4 |
| ≤ 1,000 m | 2 |
| &gt; 1,000 m | 0 |</p>
<table>
<thead>
<tr>
<th>Natural space, amenities for recreation, cultural institutions</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance to natural space, public park, recreation area or forest (or sufficient school park)</strong></td>
<td></td>
</tr>
<tr>
<td>$\leq 500\ m$</td>
<td>6</td>
</tr>
<tr>
<td>$\leq 1,000\ m$</td>
<td>3</td>
</tr>
<tr>
<td>$&gt; 1,000\ m$</td>
<td>0</td>
</tr>
<tr>
<td><strong>Distance to cultural institutions (cultural hall, event rooms, cinema)</strong></td>
<td></td>
</tr>
<tr>
<td>$\leq 500\ m$</td>
<td>5</td>
</tr>
<tr>
<td>$\leq 1,000\ m$</td>
<td>2</td>
</tr>
<tr>
<td>$&gt; 1,000\ m$</td>
<td>0</td>
</tr>
<tr>
<td><strong>Distance to sports facilities - except own ones (public swimming pool, soccer, etc.)</strong></td>
<td></td>
</tr>
<tr>
<td>$\leq 500\ m$</td>
<td>5</td>
</tr>
<tr>
<td>$\leq 1,000\ m$</td>
<td>2</td>
</tr>
<tr>
<td>$&gt; 1,000\ m$</td>
<td>0</td>
</tr>
<tr>
<td><strong>Existing school ground</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sufficient space within building for running the school</strong></td>
<td></td>
</tr>
<tr>
<td>Space sufficient - expansion capability</td>
<td>8</td>
</tr>
<tr>
<td>Space sufficient - no expansion capability</td>
<td>5</td>
</tr>
<tr>
<td>Lack of space - expansion capability</td>
<td>6</td>
</tr>
<tr>
<td>Lack of space - no expansion capability</td>
<td>0</td>
</tr>
<tr>
<td>Free space available (unused rooms)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sufficient structures for running the school</strong></td>
<td></td>
</tr>
<tr>
<td>Sufficient structures</td>
<td>8</td>
</tr>
<tr>
<td>Slight adoptions necessary</td>
<td>4</td>
</tr>
<tr>
<td>Moderate adoptions</td>
<td>2</td>
</tr>
<tr>
<td>Significant adoptions necessary</td>
<td>0</td>
</tr>
<tr>
<td><strong>Possibility to gain added value by usage for further (educational) purposes</strong></td>
<td></td>
</tr>
<tr>
<td>Already existing usage</td>
<td>8</td>
</tr>
<tr>
<td>Possible usage in future</td>
<td>6</td>
</tr>
<tr>
<td>No usage possible/ favored</td>
<td>0</td>
</tr>
</tbody>
</table>
Assessment of the "Priority" for school building renovation.

<table>
<thead>
<tr>
<th>School development</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development of school enrolment and pupil number</strong></td>
<td></td>
</tr>
<tr>
<td>Influx and increase</td>
<td>7</td>
</tr>
<tr>
<td>Constant population size</td>
<td>3</td>
</tr>
<tr>
<td>Outflow and decrease</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lack of space for school-operation in general (due to high number of pupils)</strong></td>
<td></td>
</tr>
<tr>
<td>Acute lack of space</td>
<td>6</td>
</tr>
<tr>
<td>Space is more or less sufficient</td>
<td>2</td>
</tr>
<tr>
<td>Free space available</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lack of functional rooms within school-building (due to new educational requirements)</strong></td>
<td></td>
</tr>
<tr>
<td>Acute lack of rooms</td>
<td>6</td>
</tr>
<tr>
<td>Rooms available (incl. slight adoptions)</td>
<td>2</td>
</tr>
<tr>
<td>Free rooms for other purposes available</td>
<td>0</td>
</tr>
<tr>
<td><strong>Population and neighborhood development</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Development of population size within district/ municipality/ school catchment area</strong></td>
<td></td>
</tr>
<tr>
<td>Influx and increase</td>
<td>5</td>
</tr>
<tr>
<td>Constant population size</td>
<td>1</td>
</tr>
<tr>
<td>Outflow and decrease</td>
<td>0</td>
</tr>
<tr>
<td><strong>Need of space for other purposes (cultural or leisure activities, clubs, etc.)</strong></td>
<td></td>
</tr>
<tr>
<td>Existing need is not covered</td>
<td>4</td>
</tr>
<tr>
<td>Need of space for new planned activities</td>
<td>1</td>
</tr>
<tr>
<td>Existing and planned needs are covered</td>
<td>0</td>
</tr>
<tr>
<td><strong>Building structure</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Existing structural damages</strong></td>
<td></td>
</tr>
<tr>
<td>No evident damages</td>
<td>0</td>
</tr>
<tr>
<td>Slight damages (easily repairable)</td>
<td>1</td>
</tr>
<tr>
<td>Damages (certain effort necessary)</td>
<td>3</td>
</tr>
<tr>
<td>Substantial damages</td>
<td>7</td>
</tr>
<tr>
<td><strong>Sufficient structures for running the school further on</strong></td>
<td></td>
</tr>
<tr>
<td>Sufficient structures</td>
<td>0</td>
</tr>
<tr>
<td>Slight adoptions necessary</td>
<td>3</td>
</tr>
<tr>
<td>Significant adoptions necessary</td>
<td>8</td>
</tr>
<tr>
<td><strong>Overheating</strong></td>
<td></td>
</tr>
<tr>
<td>No overheating (less &lt;5% school time)</td>
<td>0</td>
</tr>
<tr>
<td>Overheating notable, some complaints</td>
<td>3</td>
</tr>
<tr>
<td>Significant problems with overheating</td>
<td>7</td>
</tr>
</tbody>
</table>
### Measures to meet fire or other safety regulations

- High priority to guarantee safety ........................................... 8
- Measures necessary ........................................................................... 4
- Slight adoptions necessary ............................................................... 1

### Barrier free access to school facilities

- Existing for at least all main spaces ........................................... 8
- Existing only for one floor .............................................................. 4
- No barrier free access possible ......................................................... 0

### Building services and energy supply

#### Energy supply with renewables (for heating)

- Fossil based ................................................................................. 6
- Supply with RES > 50% ................................................................. 3
- Supply with RES > 80% ................................................................. 0

#### Energy supply with renewables (for DHW)

- Fossil based ................................................................................ 4
- Supply with RES > 50% ................................................................. 2
- Supply with RES > 80% ................................................................. 0

#### Energy supply with renewables (for electricity in general like PV, CHP, etc.)

- No generation on-site ................................................................. 4
- Supply > 50% < 80% ................................................................. 2
- Supply with RES > 80% ................................................................. 0

### Significant energy use (> 125 kWh/m².a or 150 kWh/m².a) for H/DHW

- High energy use ................................................................. 6
- Moderate to high energy use .......................................................... 3
- Moderate energy use ................................................................. 0

### Significant electric energy use for lighting (20 kWh/m².a or 25 kWh/m².a)

- High electric energy use ................................................................. 6
- Moderate to high electric energy use .............................................. 3
- Moderate electric energy use .......................................................... 0

### Installed ventilation system

- No ventilation system ................................................................. 8
- Partially installed system (exhaust air) .................................................. 6
- Outdated/ insufficient ventilation ......................................................... 5
- Ventilation system with heat recovery .................................................. 0
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