"The Reconstruction of Facade Openings of the Educational Building of Széchenyi István University of Applied Sciernces, Considering the Improvement of Life Quality and the Utilization of Solar Energy",
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THE RECONSTRUCTION OF FACADE OPENINGS OF THE EDUCATIONAL BUILDING OF SZÉCHENYI ISTVÁN UNIVERSITY OF APPLIED SCIENCES, CONSIDERING THE IMPROVEMENT OF LIFE QUALITY AND THE UTILIZATION OF SOLAR ENERGY

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Abstract:

The process of converting the Széchenyi István University Of Applied Sciences into University suggests a wide range of architectural tasks from inserting the prospective campus into the urban structure through the erection of new buildings to the reconstruction of the existing buildings.

In the following study the facade reconstruction of Educational Building will be shown with the main principles of the complex energetic approach, the elaboration of energy saving and the utilization of renewable energy-sources and the statement of advantageous economic refund. Besides gaining institute development financial sources, this project can also compete successfully for appropriation of increase of building value.

1. INTRODUCTION

The process of converting the Széchenyi István University of Applied Sciences into University suggests a wide range of architectural tasks from inserting the prospective campus into the urban structure through the erection of new buildings to the reconstruction of the existing buildings.

In the followings, a proposal will be put forward about the complex renovation of façade wall openings of the Educational Building with an energy saving approach. As an information one must mention that **approximately** 40% energy saving can be obtained by the project of the change of windows and the realization of shading system which utilizes the solar energy at the same time and that can take a part in the electric current supply of the school.

The project can be described through several present data and index of returns after the expected connection to the EU:

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The main data of the project of openings and shading constructions of Educational Building and the examination of the returns are:

The investment (demolition, transport, construction are included) equals gross 361 millions HUF (1,36 millions euro) of expenses happening at once. The sum above is the 9,7 % of the budget of the Institute Development Project (IDP) for the term 2001-2004.

The measure of heating and electric energy saving, counted on the present prices is: 9 + 2 = 11 millions HUF (41 300 euro) per year (the price of heating energy is 1600 HUF (6 euro) per GJ; electric current costs 20 HUF (0,075 euro) per kWh).

If the saving is counted with the effective values of EU it equals 18,3 + 13,5 = 31,8 millions HUF (120 000 euro) per year (then the price of heating energy is 3200 HUF (12 euro) per GJ; electric current costs 135 HUF (0,5 euro) per kWh).

The simplified returns counted with the current energy prices of EU is: T = 361 millions HUF / 31,8 millions HUF per year = approximately 11 years.

Focusing on the solar cell the returns can be 17 millions HUF / 13,5 millions HUF per year = 1,25 years (!).

2. GOALS AND SOURCES OF THE PLANNED FAÇADE RECONSTRUCTION

This project is linked with the Institute Development Project of 2001 – 2004. For realizing the IDP, an amount of 3,7 thousand millions of HUF (13,9 millions euro) state financial source will be competed for. The common interest of the institute and the board of judges is that the exposable returns index of the use will be the highest. That is why not only the erection of new building is justified but the modernization of existing buildings – indeed the application of new energy saving constructions.

The goal of the project is to change the out-of-date facade wall openings of Educational Building to up to date openings with increased insulating ability with regard to carrying the outer shading of the South facade wall out which has increased solar heat loading. The rationalization of energy is in the centre of interest of the European Union. With energy saving and solutions, which utilizes renewable power the Institute, can compete for state financial sources for institute development successfully.

3. THE PRESENT PROBLEMS AND THEIR MAIN CAUSES

3.1 THE OPENINGS

On the front wall of Educational Building of the Institute (built in 1976) the rate of the glazing of openings is 53%. This high value is bound up with the modern architectural approach that focused on the harmonization of the natural and artificial light in the buildings.

The planned reconstruction contains the change of all of the façade openings of the Educational Building except the great glass surfaces of the assembly and the profile glazing. The mentioned façade openings are the energetic “Weakness” of the building. Their constructional device is out of date. The custom designed steel frame windows of offices and classrooms with no thermal bridge breaker and the SOPRON-H aluminium frame windows of lift halls conduct the produced heat to outdoor without any disturbance. The building physical advantages of two-layered glazing do not prevail either – the noble gas filling between the glazing that is ordinary nowadays and the cover on the inner surface of the inner glazing which reduces the heat stream are missing. The wadding of the aperture of the windows are missing, therefore the air stream can be named as the main source of the heat loss.

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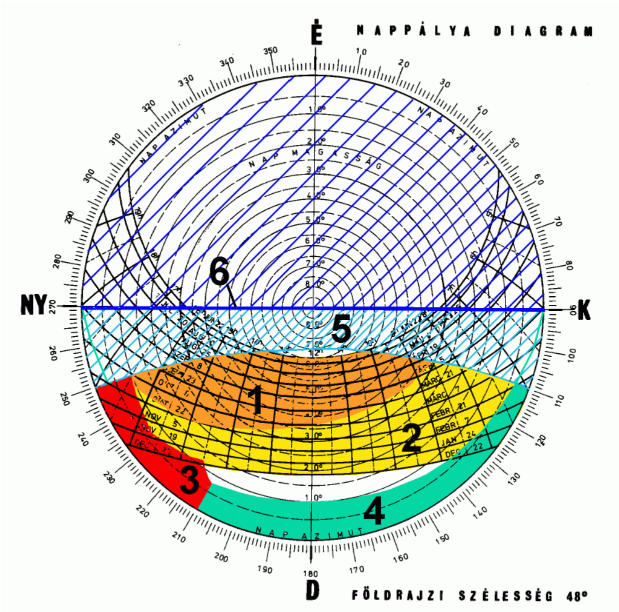
The interior space of the double-glazing intended for insulating is not closed hermetically for a long time and it is polluted. During their use, the windows became more or less obscure, which limits the visibility in significant degree.

3.2 THE EXAGGERATED GETTING IN OF SOLAR RADIATION AND THE MISSING SHADING ELEMENTS

The main façade of the Educational Building faces directly to South. Among the four cardinal points facing to this results the *highest* heat loading deriving from solar radiation, therefore on summer time in the rooms on the southern side one can measure an almost unbearable 28-30 °C instead of 22 °C that would be perfect from the view of the general feeling. This interior temperature is inconvenient for a workplace.



Solar radiation in the central point of the row of window of the third floor of the wing C of the Educational Building on the southern façade. 1=the probability of over heating is min.10%; 2=the field of Sun; 3=the buildings nearby; 4=vegetation; 5=the zone of missing rays because of their angle of incidence that is higher than 70°; 6=the façade wall.

The cause of the high temperature in the rooms is the greenhouse effect, which takes place in the interior places of the building. The solar radiation (electromagnetic radiation) penetrates through the glazing and on the surface of the so-called heavy constructions (floors, walls) absorbs it, then it turns into heat. The great mass of constructions emits long wave heat radiation that cannot get out through the glazing. Hence, one can state that efficient shading is a solution, which impedes the solar rays to getting into the inner side of the glazing; an element, which is on the outer side of the windows.

At the time of the construction, outer shading system was not set up because of economic causes. The cover, which reduces the solar radiation, is missing from the interior surface of the outer glazing. Only a low-efficiency interior shading shutter was equipped to the windows. The execution of building climate system, whose construction and, indeed the operation is expensive, did not occur, and it is not recommended to apply that considering the energy saving.

4. STEPS THAT HAVE BEEN TAKEN PREVIOUSLY

Energetic (thermovisional) examinations have been done about the Educational Building as a whole and about the façades by dr. Péter Tóth, associate professor. A part of his proposal has been carried out already despite the limited financial sources. The heating system of the rooms on the

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northern side of the building and the rooms on the southern side has been divided into two considering the adjuster technical aspects. Thus, the cold of the northern rooms and the overheating of the southern rooms, which had been also warm in the sunny winter days, could have been reduced. Almost every aperture of the windows has been sealed with long-lasting elastic putty (TR) except for the openable ones, which have been left without wadding. Dr. Elemér Tallós, the former deputy headmaster of the Institute proposed to realize the missing shading constructions in the eighties.

5. TECHNICAL ALTERNATIVES OF THE PLANNED RECONSTRUCTION. PROPOSED SOLUTIONS

The main principle of the reconstruction is the *complex energetic approach* that means the project intends to be accomplished in the spirit of the European demands and the recent home energetic norm.

For the solution of the raised questions above – after a careful analysis – the mostly proper constructions were chosen. The effectiveness of the proposed constructions is to be examined with energetic calculations, where the energy needs of wintertime and the gain coming from the solar heating is to be borne in mind. At the process of design of the outer shading the solar heat loading in summertime is to be demonstrated and the active utilization of solar energy is to be recommended.

5.1 ENERGY-SAVING OPENING CONSTRUCTIONS

The main static consideration at the change of the openings is that the windows (size in general: 150/130 cms) link to an inclined one (size in general: 150/84 cms). Among the frames of openings made of several materials, only the timber and metal windows are suitable – as the present construction – for bearing the load of the oblique windows and its load of snow in wintertime without a secondary supporting construction.

Despite its advantageous price, the plastic openings are not suitable in our case because of the static cause described above and their relatively fast ageing (which derives from he UV radiation).

The maintenance of the oblique windows is much more complicated than the vertical ones. In case of timber windows in the frequent change of temperature and humidity, the timber frames of oblique openings would fall into deterioration without systemic maintenance. The timber frames can not be chosen in the respect of architectural view, they do not fit in the milieu of concrete-glass-steel materials.

Thanks to the manufactured wadding, the cover that reduce the heat loading, the noble gas filled double glazing and the special thermal bridge breaker frame constructions, the heat insulation abilities of both of the aluminium and the steel frame windows.

At the project of the reconstruction of façade wall openings of the Educational Building, the application of aluminium frame windows is more advantageous than the application of steel frame windows. The price of steel frames includes the high strength that can be refunded only in case of extended height (two or three floors). In the examined situation the glazed surfaces are merely one floor high, then the expenses of execution with thermal bridge breaker aluminium frame windows can be 15% less than with steel material.

A unit of openings of offices and class rooms means a vertical window in connection of an oblique window and a smaller vertical blind window with an aluminium sheet refill. For the interest of the advantageous architectural look of set of window units and constructional causes, it is favourable to apply curtain wall frames instead of common window frames. An other reason is to choose the precious contraction is the necessary increased drain supply of the oblique openings. Since these windows take place in units, the whole unit has to be made from the same construction.

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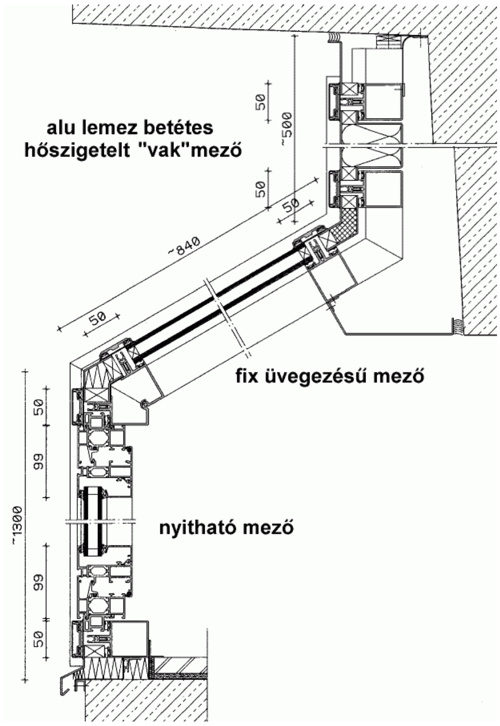

The suggested renovation of the openings of offices and rooms with aluminium curtain wall frame constriction and insulating glazing

The suggested solution to the southern façade wall is the thermal bridge breaker aluminium curtain wall frame with double glazing windows; a cover is needed on the interior surface of the inner glazing that reduces the heat flood to outside (the "k" value of the construction is 1,5 W/m2K). Accepting the recent safety norms, the width of the joined and layered glass of the inclined window has to be at least 6 mm (2x3 mm with special foil). The motorway that links Sziget and Révfalu will be built up in the near future 150 m far away from the southern front of the examined building, that is why it is important that the constructions has to suit the noise impediment requirements. The suggested openings are appropriate from this point of view, thanks to the double-glazing and the manufactured wadding.

One can suggest that the blind window with aluminium fill over the oblique one has to be executed as an insulated aluminium sheet cladding zone instead of a part of the curtain wall. These alternatives are close to each other from the view of look but the previous one can be 100 000 HUF (375,4 euro) in savings, altogether in the building 60 millions HUF (225 200 euro).

On the southern façade, a greater solar heating benefit can occur, but on the other side, the rooms on the northern side are definitely cold. The substantial difference has to be borne in mind at the application of up-to-date constructions. There are several alternatives for solution. The triple glazing instead of double increases the insulating abilities but it is useful only if a considerable improvement of noise insulation is necessary. The cover mentioned before also can improve the insulation abilities in a high rate (the "k" value can be decreased from 2,5 to 1,3 W/m2K). If the space between the double glazing is filled with noble gas, the "k" value obtain 1,1 W/m2K. the use of transparent insulation between the double glazing of the inclined openings, which let the light in the form of scattered light. The noble gas filling between the glasses is not justified on the southern façade because of the considerable heat benefit in wintertime and on the eastern and western front because of the function of areas. If the most effective outdoor shading

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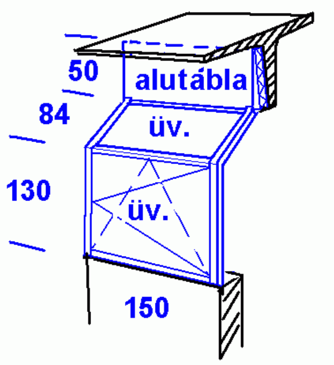
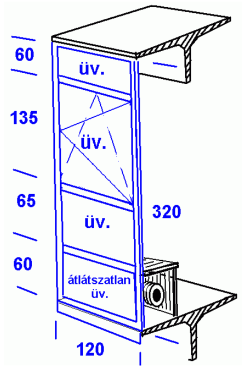
materializes (see next point) than the cover that decreases the solar loading of the inner side is not justified any more.

Bearing the different solutions in mind one can suggest that – differing from the openings on the southern front wall – the openings on the northern façade has to have noble gas filling between he glazing, where the insulating glazing has a foil, which lessen the heat floating outside (the “k” value of this construction 1,3 W/m2K). The suggested gas filling increases the price of glazing by 3-5 thousand HUF, depending on the type of the gas (it is 10 millions HUF /3750 euro/ in the complete project).

Keeping the principle of the existing form of assembled wall is suggested because the change into vertical frame would be advantageous aesthetically but the cost would be increased up to 240 000 HUF (instead of 180 000 HUF) per unit, which can be higher by the costs of scaffolding that is necessary in case of application of curtain wall. The problem of putting the units continuously can be solved with the use of the half size frames.





A unit of the openings on the southern and northern side and the unit of openings of the lift halls on southern and western side

It is suggested to apply the thermal bridge breaker aluminium frame assembled glass wall with double glazing, with the thermal foil on interior surface of the inner glazing (the “k” value of the construction is 1,5 W/m2K). The noble gas filling is not necessary because the walls face to West and East. Focusing on the better look it is suggested to apply opaque glass in the field below instead of the existing aluminium sheet cladding. It is protected from the interior space with an aluminium screen with radiator.

5.2. UP-TO-DATE ENERGY PRODUCER SHADING SYSTEM

At present time the inclined glazing on the southern side are disadvantageous, from many side of view: the solar loading is high and it is difficult to keep them clean. A preferable technical supply can solve the shading and the utilization of solar energy in one: that is the shading solar cell plate.

It is well known that the most effective shading is the outer shading (the lowest effectiveness has the shading solution that is used at present). Keeping the costs of installation and the needs of free lookout through the town in sight, that is better to apply the almost horizontal shading in one piece than the shutter style. That is why it is suggested the building of the lacking shading over the inclined glazing surfaces with the application of solar energy transformer photovoltaic modules.

The ancestral principle of the outer shading can be observed in the rustic architecture of several groups of people and at the smart solutions of ancient Hungarian farmer houses. The main feature is that the shading protects against the sunshine in summertime but it lets the sunshine in at wintertime.

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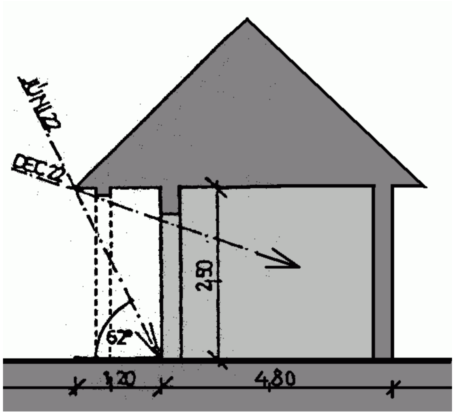

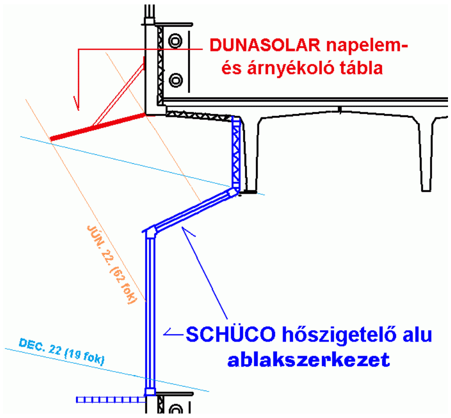

The rates of an ancient farmer house and the conditions of sunshine and a sketch of the suggestion for shading the southern windows with solar cell units

The solution that the shading is a system of solar cells in one is particularly competitive in the respect of the competition of the World Bank aimed to the energy saving.

As an example, the technical properties of a home made solar cell (and shading) module are described below.

Size: 1245x635 mm (standard) / *Surface*: 0,8m2 / *Output*: 40 W per module / *Electric Power Product* (estimated): 32 kWh each modules per year / *Price of one Unit*: 46 000 HUF (tax included) (173 euro) / *Cost of Investment and Installation of one Unit*: 66 000 HUF (tax included) (248 euro)

The most advantageous angle of the sheet of the solar cell and shading elements is determined with the SOLARPLAN solar cell-designer computer program. The effectiveness of the solar cell is the highest in June and July when the term of direct sunshine is longer. That is why it is valuable to decide to use these elements in this period. In this case, the optimum angle of the solar cells is 10 degrees. To optimise the angle, a lot of thing has to be considered (expected weather, clouds, etc), which are described with a characteristic graph. This graph points out the fact that in the known circumstances the direct solar radiation is the most advantageous around 2 p.m. in June and July, which concludes the optimum angle of photovoltaic elements.

6. ARCHITECTURAL APPEARANCE

The planned reconstruction keeps the geometry of the existing vertical and oblique glazing, only the construction of openings will be renovated, but the shading system will be a new element on the front wall, which can modernize slightly the appearance of the concrete-glass-steel building.

At the process of architectural design, the ability of keeping clean has to be solved, which is a problem at present. The rail and cleaning basket system on the front walls is insoluble because of the appearance of the attic wall; it is far back from the frontal plane. The alpine technology can be an other solution but it seems to be difficult at the first sight and that is why expensive. A 40 cm wide cleaning screen at the edge of each window, both the southern and northern side can be mostly the best solution.

The outer surfaces of the assembled walls at the lift hall can be cleaned easily, because every second window is not fix in the row of the plane wall, from where the farthest points of the glazing are attainable without trouble.

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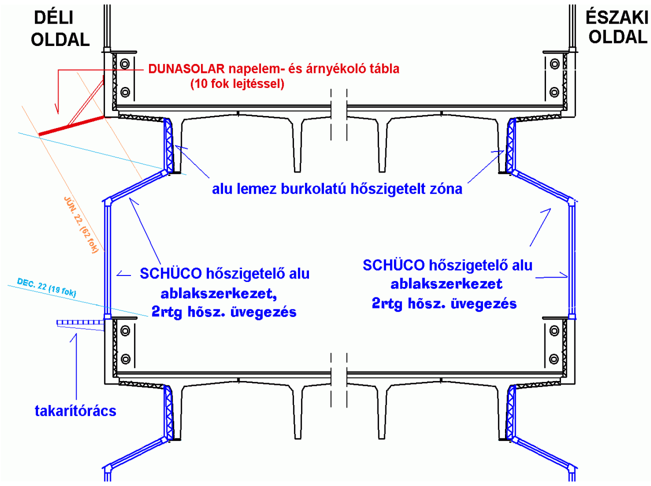

The planned state

7. THE COMPLEX BUILDING ENERGETIC CALCULATIONS

The energetic controlling calculations – in the spirit of new norm – bears the specific shape of the building, the transmission heat loss, and the solar heat benefit of glazed surfaces.

As an example, the heat loading of the offices on the third floor of the wing C is demonstrated before and after the renovation.

In the energetic calculation the volume of heated areas, the solid surfaces of the front wall, the glazed surfaces (with their shading features and the point of the compass), and the linear heat bridges. With the effect of infiltration in the calculations one must bear the existing windows with the "k" value of 3 W/m2K (measured data) instead of the "k" value of 2,2 W/m2K that was given from laboratory.

By the results of calculations to the *present condition*, one can state that the specific heat flow (0,32 W/m3K) is above the limit value (0,239 W/m3K) of valid norm in a significant degree. At the time of construction the norm of that time did not focus on the energy saving; the regulations were much milder than the EU norms of present (EN 832).

It is a striking data that because of the bad quality of opening constructions and the lack of solar heating benefit the heat loss is two times more on the northern side than the southern side.

It is important to sign that the approximate energetic computation showed 21,4 W/K heat flow that does not differ on the point of compass. Preceding local measurement proves that on some special winter days when the sun shines durably, the temperature on the surface of the southern front wall gains the heating temperature. Then the heat flow stops, so the heat loss of interior areas converges to zero, or either, there is heat benefit! This advantageous phenomena at the parapet wall is not considered in the norm, only rules to keeping the point of compass in mind at glazed surfaces are given.

Based on the results of the calculations to the *planned condition* one can state that the heat flow with the planned constructions (0,14 W/m3K) is considerably below the limit value (0,239 W/m3K) of valid norm. The heat loss after the renovation will be less than 50% of the present time. Besides that the advantageous energetic properties of the suggested constructions can be shown in the calculation of the planned condition, it is obvious that the exaggerated solar loading of the inclined glazed surfaces comes to the end after the installation of shading elements. It is important to declare that the requirements about the natural lightening of rooms will be fulfilled after the planned reconstruction.

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8. THE MEASURE OF COST SAVINGS OF HEATING AND ELECTRIC POWER AFTER THE RECONSTRUCTION

8.1. THE COST SAVINGS OF HEATING ENERGY

By the energetic controlling calculations, the reconstructions results a decrease of heat flow from 170,6 W/K to 79,6 W/K (data valid to the wing C on the third floor), so the costs of heating energy can be reduced to 50%. As a rough approach one can state that the 40% of energy saving can be counted for the complete building, which means nine millions HUF (33 780 euro) per year on the present energy prices.

8.2. THE COST SAVINGS OF ELECTRIC POWER

Thanks to the cell-shading units on the vertical windows – indeed the inclined windows – the exaggerated solar radiation can be impeded. This results that the state of air in the southern side rooms gets back to normal. The solar cells (with an angle of 10°; size 0,8m2) applied on the southern façade wall produces an average 312x32 kWh = 100 000 kWh. By a departmental order, this can be borne in mind with a commercial price of 20 HUF per kWh. That means the electric power savings accelerates two millions HUF (7500 euro) per year.

8.3. THE HEATING AND ELECTRIC ENERGY SAVINGS IN ALL

The total savings of heating and electric power (from 8.1 and 8.2) 9 millions HUF + 2 millions HUF = 11 millions HUF (41 300 euro) per year.

9. THE ESTIMATED COST OF THE PROJECT

9.1. THE MOST FREQUENT ELEMENTARY CONSTRUCTIONAL UNITS

Giving a summary of the project, it is suggested to change the openings to the followings. On the southern front wall the application of the thermal bridge breaker aluminium curtain wall frame with double insulating glazing, where the inner glass has a heat floating lessening cover, and the application of solar cell-shadings, on the northern front wall the glazing completes with a noble gas filling.

Because of the several sizes of openings, one must describe the openings stock *approximately* with three characteristic constructional units. The fairly accurate price is suitable to prop the decision-making up, for the reason that 80% of the stock is built up from these three chosen type and the remaining 20% is also can be described easily with a fourth (substitution) one. The net price of the constructional units includes the demolition and transportation of existing openings, providing the continuous operation of the building and the installation of the new constructions. The cost of the investment of solar cell-shading units includes the price of supplements and the installation.

9.2. THE ESTIMATED COST OF THE RECONSTRUCTION OF OPENINGS

The Price of the Construction Units (with the cost of demolition and installation)	**Location**	**Piece**	**Price**
1. Curtain Wall I. (300 000 HUF)	Southern	312	94 M HUF
Solar Cell-Shading (55 000 HUF)	Southern	312	17 M HUF
2. Curtain Wall II. (302 000 HUF)	Northern	312	94 M HUF
3. Assembled Wall I. (258 000 HUF)	Eastern&Western	236	61 M HUF
4. Assembled Wall II. (260 000 HUF)	Northern	89	23 M HUF
Altogether: 289 millions HUF + 25% TAX = 361 millions HUF (1,36 millions euro)			

This sum is suitable for the IDP.

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10. THE MAIN LESSONS OF THE ARRANGEMENT OF THE RECONSTRUCTION

The façade reconstruction of the Educational Building requires complex approach and prudent planning. Only this way can the faults be prepared that were built in 30 years ago, whose sources were the constrained savings and the lack of respect of the energy.

The prospective effectiveness of the project can be described with the returns index after the EU connection as is it was shown in the introduction.

It is thought provoking that the simplified returns period of the solar cells is merely 1,25 year counted in EU prices. The simplified return period (11 years) of the whole project is also derives from this. The returns of the reconstruction of openings without the solar cells would be 18 years.

It is valuable to weigh that if more solar cells are installed on the great dimensional flat roof of the Educational Building in the value of 40 millions HUF then the returns period of the whole project (in the value of 400 millions HUF) would be less than seven years.

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