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THE MODEL OF THE TRANSFORMATION OF A COMMON OFFICE BUILDING INTO THE CHARACTER OF A GREEN BUILDING WITH THE TARGET PROGRAMME INTO A SUSTAINABLE BUILDING WITH ZERO BALANCE OF THE ENERGY FROM THE NETWORK

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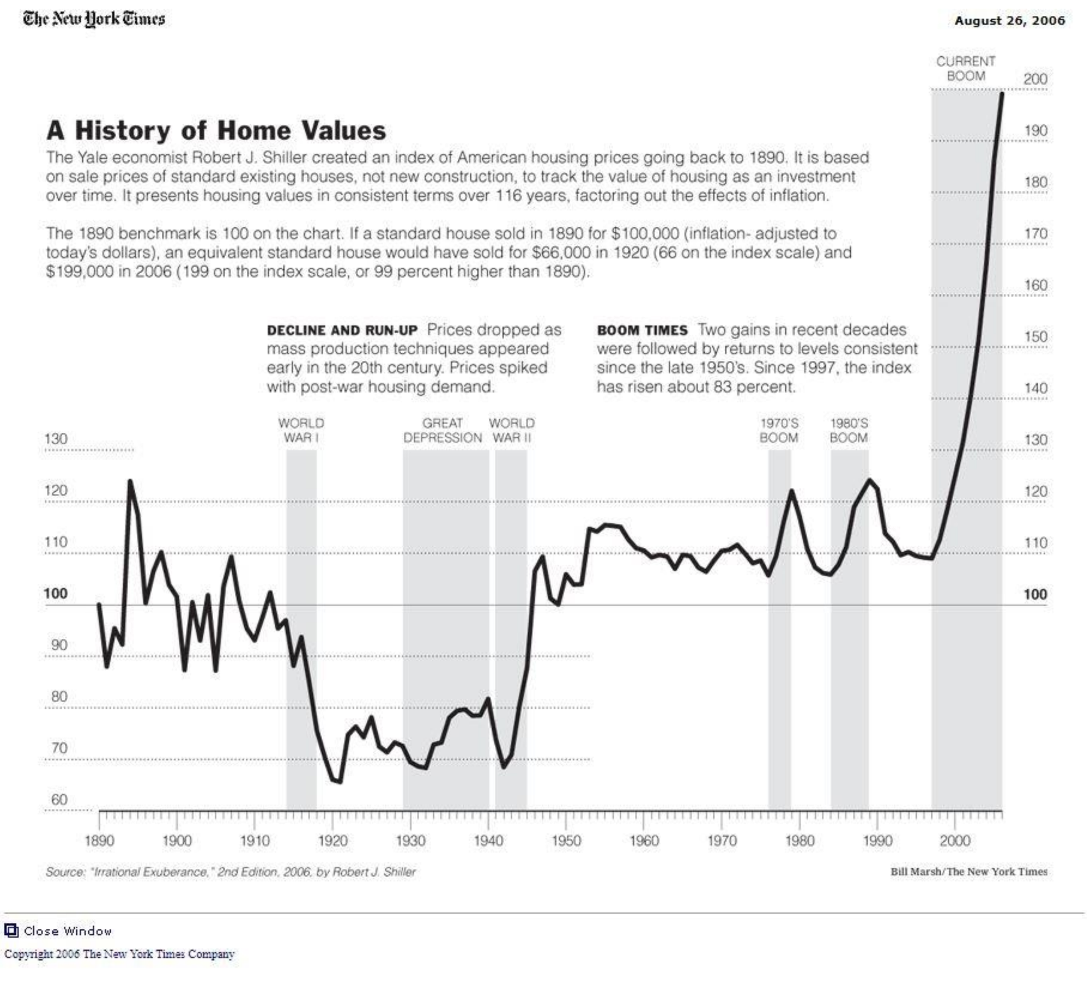
1. INTRODUCTION TO ENERGY TRANSFORMATION OF BUILDINGS

The basic aim of the transformation of buildings is the preservation or increase of their economic values within the harmonisation of the aims of energy effectiveness and ecological criteria. It is possible only within the harmonisation of the parameters of economic space expressed in the laws with social aims. The analysis of the Shiller´s Index Development of Real Estates Prices since 1890 - picture no 1 - confirms that from the economic point of view buildings fulfil the function of the preservation of the value in time. The average growth of the values cleansed of the inflation represents 2‰ per year. Buildings represent an important wealth of the society and up to a certain level they also stabilize a part of the economy within the national economy.



Picture no 1 Shiller´s Index Development of Real Estates Prices in the USA.
(Shiller, R.J., 2011) [1]

The period related to the WWI and WWII and Great Depression between the wars from 1910 to 1940 in combination with the progress in technological development of the houses construction moved the real prices of real estates in average by 30% lower than the original value in 1890 was. On the contrary, from 2001 to 2006 the prices doubled and then rapidly went down along with the price course corresponding to a typical course of social polarization model, i.e. the market characterized as the market with the presence of asymmetry in information between a consumer and an investor with the artificial stimulation of the market in favour of investors and formation of moral hazard for a consumer. An expected return of real estates into the prices on the level of 110 points sometimes around 2015 means that the real estates increased the value by 10% in 125 years. It says ***that real estates generally maintain the values in time.*** The real estates have the nature of long-term investments for 100 and more years. The reconstruction and also the improvement of the equipment quality is necessary during their lifetime, whether they are the issues related to the aesthetics, expanding the functionality, quality of internal climate or safety and energy efficiency. The only way how to achieve the preservation of the building value within a long time is the compliance with the criteria of reconstruction that does not cause the building value loss as a result of physical or moral depreciation. Once the prices of buildings rise on the balanced market, i.e. the demand goes up; the market sensitively reacts and immediately saturates the increased demand by a new offer and copes with the imbalance in the horizon of several years.

Nowadays there exist the following basic economic incentives leading to the restoration of buildings and their transformation in the target state of buildings with zero energy needs:

- ***They are the climate changes and related occurrence of thermal waves causing a significant increase of the risk of organism collapse because of the heat with a possible fatal end. The solution is represented by the improvement of the quality of internal environment by the function of the cold during the summer period while respecting the human physiology.***
- ***Permanently increased price of fossil fuels with the acceleration of the pace of price rise since 2015 as an impact of expected switch of the oil market to a decreasing trajectory of market supply with the rate of decline from 2 to 4% per year combined with the potency of charging the CO_2 emissions.***
- ***The increase of a building profit if the local energy sources supply the building with more energy than they consume.***

The reduction of energy consumption needed for a building service represents one of economic sources that cover the investments. The second one is the preservation of a building occupancy because reduced operational costs enable the effective price competition within the expanded range of services. They are additional profits, e.g. the impact of expanded range of services by the cold together with increased quality of internal climate that provide the second part of economic sources that enable to solve long-term financing of investments.

The gradual realisation of the transformation of office building is made so that it first meets the criteria of an energy-efficient building, then the criteria of a green building and an intended target is represented by the achievement of the state with zero energy balance in the clearing point with distribution networks or the achievement of such a balance that ensures the use of technical potential of local renewable energy sources and places the energy surplus against the building consumption in the distribution networks. It is a long-term project realized during 20 years. The time distribution of the investments with a precise timing regarding the conditions on the market enable to realize the investments from the internal sources of a building itself in full operation. If the financing from external credit sources is used, these investments are again paid from the internal sources of building. This principle forces to search the solution that enables the implementation of the investments in full operation of the building. No grants or external financial sources were used for the realisation of the building transformation that would not be the subject to repayment from internal profits of the building. The used technologies harmonize the economic possibilities of the building and ecological requirements and show that to be economic does not exclude being ecological, too. The main incentives for the transformation of a building include:

1. ***the reduction of operational costs of buildings by the means of energy efficiency***

2. ***the reduction of the CO_2 emission production related to the energy supply consumed in a building and thus the reduction of future costs connected to the fees for CO_2 emissions released into the atmosphere reflected in the energy prices***
3. ***pro-active strategy of the elimination of increased risk related to the price rise of energy from the fossil fuels as a result of their increased consumption and an expected decrease of market supply by transition through the Hubbert break***
4. ***the increase of the range of the provided services by the cold and therefore providing of required temperature of internal climate with the positive impact on the productivity of worker´s performance***
5. ***the change of the way of the energy transport especially from the conventional method to predominantly radiant system - the solution provides a higher quality of internal climate more suitable for the human physiology with a result of the reduction morbidity, headaches, allergies, etc.***

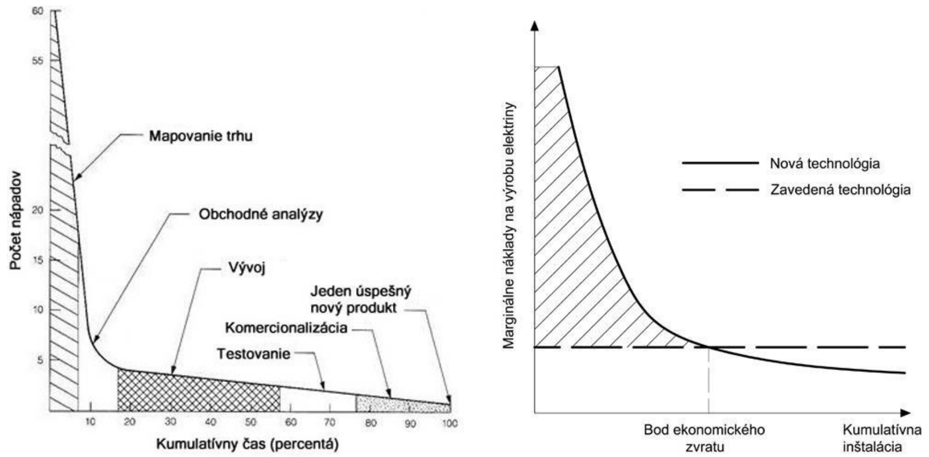
It is necessary to evaluate the following facts within the determination of the project of a building transformation:

1. Building - its architecture, construction and the mode of operation
2. The state of the technologies on the market that enable to solve the energy efficiency of a building individually for separate energy carriers, heat, cold and electricity, eventually their combination in the synergistic effect of their technical and economical parameters
3. Available local renewable energy sources, their quality and quantity, i.e. the ability to provide the required energy output in real time of economic process for a corresponding energy carrier
4. Technical and economic state of the technologies of a corresponding energy carrier enabling the conversion of the energy from the local renewable energy sources for a required economic process in a building

The measuring in the laboratories and corresponding energy models only rarely describes the reality in the building accurately. It is the result of the fact that buildings are characterized by huge amount of mass and a whole system of variable parameters connected to a concrete building. Without the correction of the models on the basis on measured parameters, the literature points to the fact that the models elaborated on the basis of laboratory measuring often reach the accuracy of only about 50%. The method of real operation of a building also represents a significant impact on the parameters. The behaviour of an operator and users is individual and it can significantly influence implemented conditions in the form of parameters into models and therefore significantly influence the values of calculated parameters. A qualitatively different problem is that while the technology is used for the first time in pilot project, it is possible to gradually eliminate the identified problems from implemented solution only by detailed measuring and analysis of gained data. Two or three-year verification in practical operation represents the standard time for the achievement of necessary knowledge and their projection into project documentation. ***Therefore the measurements in site in real operation of a building play an important role for the future projecting as a tool for achieving a corresponding know-how.*** The costs of pilot project related to the verification of the procedures and their subsequent correction are normally released into the costs within the projection of future solutions in the form of intangible assets.

2. PRINCIPLES FOR THE SELECTION OF TECHNOLOGIES AND DETERMINATION OF TIME OF THEIR IMPLEMENTATION INTO OPERATION - KNOWLEDGE CURVE

Buildings represent a significant long-term value within the national economy where except of their mission in the form of service they also fulfil the tasks in the world of finance - they protect the investments against inflation. Their 40% share on the energy consumption creates the possibility to increase the economic value of a building by correctly performed transformation into a building with almost zero energy needs. New construction technologies of envelope structures enable to provide better energy efficiency of building service by the means of technological innovation. The eco-technologies and mainly the renewable energy sources that provide required energy output via natural process of ecosystem in real time of human economic activity are able to transform the consumption of heat, cold and electricity from fossil energy sources and create the economic value added of a significant importance after payment of the investments. Their application also reduces the CO_2 emission production related to the energy supply of buildings and also increases the range of provided services and the quality of internal climate. By the assessment of building characteristics, its construction, architecture and operational characteristics in relation to available renewable local energy sources it determines the possibilities that the nature provides by its ecosystems in a certain location for human economic activity in the form of building service. What is also important to fulfil is the achievement of investment return of realized technologies. There exist two economic sources for the investment return: energy saving and expanded range of services.



Picture no 2 Qualitative and quantitative knowledge curve (Pierce, J.A., Robinson, R.B. 1988) [6]

The analysis of long-term-above the average-successive companies has shown that ***<u>one of the important keys to success is the use of high technologies verified by the market.</u>*** While in 1970´s in average 60 different basic concepts were needed until one of them was applied on the market in the form of a product, nowadays we already need in average 300. Thus the probability of the success within the research of basic technologies went down 5 times. That is the reason within the selection of technologies in applied research and development that represents the transformation of building. It is necessary to study whether a concrete technology is on the market long enough, what the number of innovations is that it went through and especially what its future is. It is necessary to answer the question whether the actual development of corresponding technology ensures the investment return in relation to the price of money during the investment period. If not now, whether the trends in technological innovation and within the application of economy in the extent of studied technology will lead to the achievement of the economic breaking point and therefore to the investment return. It is necessary to determine how many technological cycles and within what volume of production the corresponding technology complies with the criteria of the investment return within standard market conditions. A very important criterion seems to be the criterion of synergistic effect creation within combining used technologies with waste for the expansion of provided function, technical and economic parameters. The analyses of technological possibilities by the means of knowledge curves have to be executed on two levels:

1. A qualitative level - we determine what the phase of a life cycle is where a corresponding technology occurs and what is the probability of achievement of introduction of a concrete technology on the market within the reaching of economic breaking point, i.e. within the investment return. Each phase of a life cycle is related to a certain risk that gradually goes down along with the transition from the phase of market analysis through the phase of business models and research and development up to the phase of testing and commercialization. A curve for qualitative analysis - picture no 2
2. A quantitative level - this analysis has its meaning for the technologies that reached its technological qualitative aim. Other improvement of economic parameters is gained only by increasing volume of production and competition on the market. The analysis should determine when there is the assumption of future moral obsolescence of a concrete technology.

The knowledge curve for the density of elements on the integrated circuits from 1965, known as Moore´s knowledge curve, has been showing its informative value practically up to the present days and showed the veracity and reliability of the principles of the creation of such predictions for various technologies. Actually it is necessary to evaluate both approaches to knowledge curve simultaneously and determine the qualitative criterion together with the economic criterion that determine the required technical level of parameters and also a suitable time for the implementation in the corresponding application. In the knowledge curve - picture no 2 - it is expressed by achieving the economic breaking point when a new technology gains the investment return toward the actual technologies. If we talk about the transformation of already constructed building, the considerations should include also the issue of a physical recovery and the issue of a planned obsolescence of used technologies. An ideal solution is represented by the selection of such technologies, the application of which improves the technical parameters, improves the quality of internal environment and increases the share of renewable energy sources up to the state of zero balance with energy networks. A future solution of the energy market enables the energy output of local renewable sources to supply by the energy not only a building but to place the energy surplus above the state of zero balance into the distribution energy networks. The original assumption that the transformation of energy networks in site marked as "smart grid" provides a significant saving on the side of a consumer is not being fulfilled. It is expected that the investments into the technical equipment of distribution network within the savings of 1 to 2% will not be interesting for a consumer. The made investments will be able to recover only after providing the supply of energy surplus within the use of technical potential of local energy sources of the building in the distribution network. It significantly increases the technical use of energy source and therefore its economic parameters. The technology of heat pumps is assessed according to the seasonal performance factor SPF that determines the ratio between the supplied energy and the consumed energy for the power of devices of energy source. The state of zero energy balance in the clearing point between the building and distribution networks plays a similar role. The state between the energies locally supplied by energy sources of building and distribution networks is studied.

3 THE DESCRIPTION OF A COMMON OFFICE BUIILING APPLIED FOR A MODEL OF ITS ENERGY TRANSFORMATION

3.1.1 FUNCTIONAL AND OPERATIONAL SOLUTION OF A BUILDING

A building has got a character of a non-residential building designed for administration and management, for banks and post-offices. The building has a concrete frame construction that makes possible to structurally adjust the interior according to the required needs. It has got 6 above ground floors and one underground floor. The built up area of the land is 629m^2. The second part of the building is integrated to the building – an extension on the built up area of 311m^2 with three above ground floors, corridors integrated with the building. Regarding the used construction the space of the second and third floor has the extensions with the area of 326 m^2. The building includes also a protected built up country yard with the area of circa 750m^{2}used for parking and garages.

The office building is operated as business centre for bank services, insurance services and advisory services of financial market, IT services, leasing services as well as the services of a legal nature, whether they are law firms, notary, bailiff, etc. as well as the operation of the management and the administration of standard business companies. The building infrastructure is adjusted to the requirements of a concrete tenant with the safety solution up to a bank category.

Picture no 3 and 4 The pictures of the office building in 3 Murgašova Street, Košice before and after the renovation of the façade.

The building is systematically designed so that on individual floors there are entire premises created and they are divided from a corridor by a separate entrance with own sanitary facilities. The standard office spaces are available with the area of 20 or 40m² within separate wings. However, the frame construction enables to handle the space according to individual requirements, what is used for example within organisation of bank spaces. Also the rooms like kitchen and similar are built according to the customers´ requirements.
It is the object built in the centre of Košice in 1980 and it has got the extension from 1985. The provided services ensure 24-hour reception service together with all media and services linked to the operation, maintenance and investment activity gradually realized in the building.

3.1.2 TECHNICAL-CONSTRUCTIONAL SOLUTION OF A BUILDING AND ITS ENVELOPE STRUCTURES

The constructional solution of the building with 7 floors (6 above ground and 1 underground floor) is subordinated to the purpose and possibilities of construction materials used at any given period. The purpose of building use defined the object as a triple tract with the offices along façades and a corridor in the middle wing along the length of the object. A support system is created by prefabricated reinforced skeleton with beams in the transverse direction in combination with brickwork forming a vertical wall construction. Windows of common dimensions, double wing, openable, originally wooden doubled are used as fill constructions. They were replaced by the plastic ones with insulating double glazing. Interior walls are made of brick. Ceiling structures are made of panels that are longitudinally perforated. Stairs are prefabricated and made of reinforced concrete. Ceiling construction is a single casing horizontal with asphalt - bitumen roofing.

The extension of the object was realized later. It has three above ground and one underground floor and uses longitudinal and transverse reinforced concrete modular basis. Ceiling structures are also panel prefabricated. The ceiling above the highest floor also forms roofing and it is made of steel truss girders with large span. Thermal-technical characteristics of the construction comply with the standardized requirements for a given period. Nowadays, the object is thermally insulated by the polystyrene isolation.

3.1.3 AESTHETIC-ARCHITECTONICAL SOLUTION OF A BUILDING

The building was architecturally designed in the period at the turn of 1970´s and 80´s. The aesthetic-architectural conception was subordinated to functionalism with the proposed use as the office building. Simple lines formed by a simple cuboid oriented longitudinally in the direction North-South ensure suitable orientation towards solar radiation, but also minimize the impact of dominant North-South winds. The building fills into the concept of surrounding housing development by its mass and shape.

In the original version the walls were fitted by the facing from the external part. The facing is made of ceramic glazed panels that form a base layer with high resistance to outdoor weather conditions. The insulation covered the facing and the surface treatment is realized from the plaster of pale blue-grey colour. The building has a positive form factor (the ratio of the area of heat-exchange package of the building to the converted building capacity) that positively influences the thermal loss of the object.

3.2 A CHANGE OF ENERGY CHARACTER OF A BUILDING

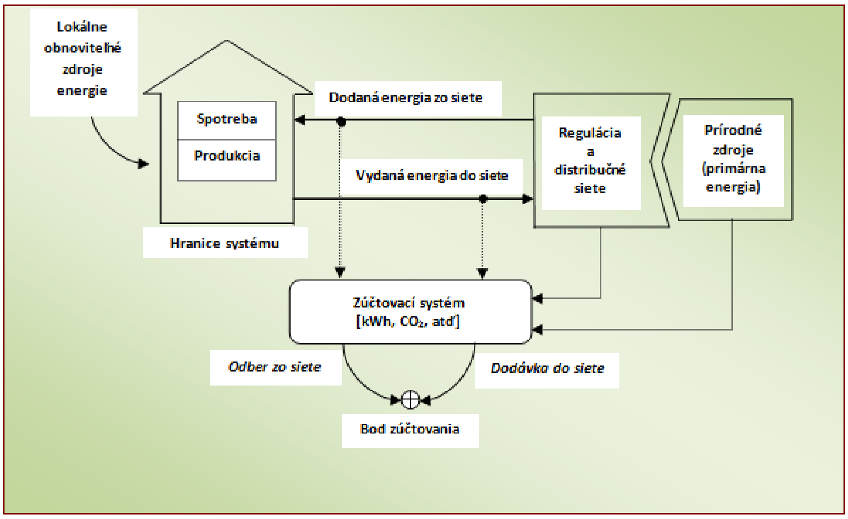
3.2.1 BUILDING AS AN ENERGY CONSUMER AND SPACE FOR CONVERSION OF PRIMARY ENERGY IN PLACE

The standard building and its operation is based on the fact that the distribution energy networks are connected to the building. It used them to supply the energy, whether it is heat, cold or electricity. The building in common operation behaves as the energy consumer. However, the local renewable energy sources can exist on the lands or spaces of the building, suitable for the technologies enabling its conversion into the form suitable for human economic activity. They are for example the hydrothermal energy sources, geothermal energy sources or solar energy. The technologies determined for the conversion of local renewable energy sources can be stored in a building or on the building roof or its sheet as well as on the surrounding lands. Therefore there exists a system boundary of the building that contains a physical part and a logical part. The physical part of the system boundary includes except the building itself also the lands under the building and the lands adjacent to the building if they are used for the purposes of the local energy source. The logical part of the system boundary consists of clearing interface of various physical quantities.

The strategy of the building transformation into a building with zero energy balance with distribution energy networks is based on the fact that in the place of the location bounded by the physical interface of a building there are local renewable energy sources whose energy output enables to cover the operational costs of the building within the use of corresponding technologies in real time in zero balance in the clearing point with connected distribution energy networks or supply the distribution networks by the energy surplus above the zero balance state in the clearing point. Thus it is determined that natural ecosystems provide a required energy output of local energy sources and thus they create the conditions for gradual transformation of a building via the energy-efficient building into a building complying with the criteria of green building up to the targeted state of a building with zero energy balance with distribution networks. The principal advantage of the solution when the energy sources are localized within the system boundaries of the building is that there are no distribution energy losses in the distribution networks. According to the type of energy carrier, the distribution energy losses form 15% to 30% of energy losses in the relation to the distance of the energy source from the building and the way of solving the distribution system. While the excessive technical potential of local renewable energy source is used, the energy above the consumption of the building supplies the closest buildings; it means that the energy losses are minimal.

3.2.2 ENERGY FROM DISTRIBUTION NETWORK AND ENERGY CONVERTED FROM PRIMARY ENERGY IN PLACE - IN BUILDING

The buildings labelled as buildings with zero energy needs have the factual sense only as the buildings supplied by local renewable energy sources that are situated in the space bounded by system interface of the building. The energy balance of operational energy consumption in the clearing point with distribution energy networks reaches zero. The initial state presents the building as an exclusive energy consumer. In the particular case being described, the energy consumption of the building in the reference period of 1996 represented 840,000 MWh a year and the electricity consumption used for the building operation is 60 MWh a year that represents 7.5%. There were many technologies available on the market for solving the energy efficiency in the period 1996-2005. Therefore they were the economic motivations that determined the improvement of the parameters of energy efficiency of buildings within the heat consumption. The solution of the cold and electricity was represented by the subsequent and partially parallel steps within the building transformation.



Picture no 5 Simple clearing system of building with distribution energy networks

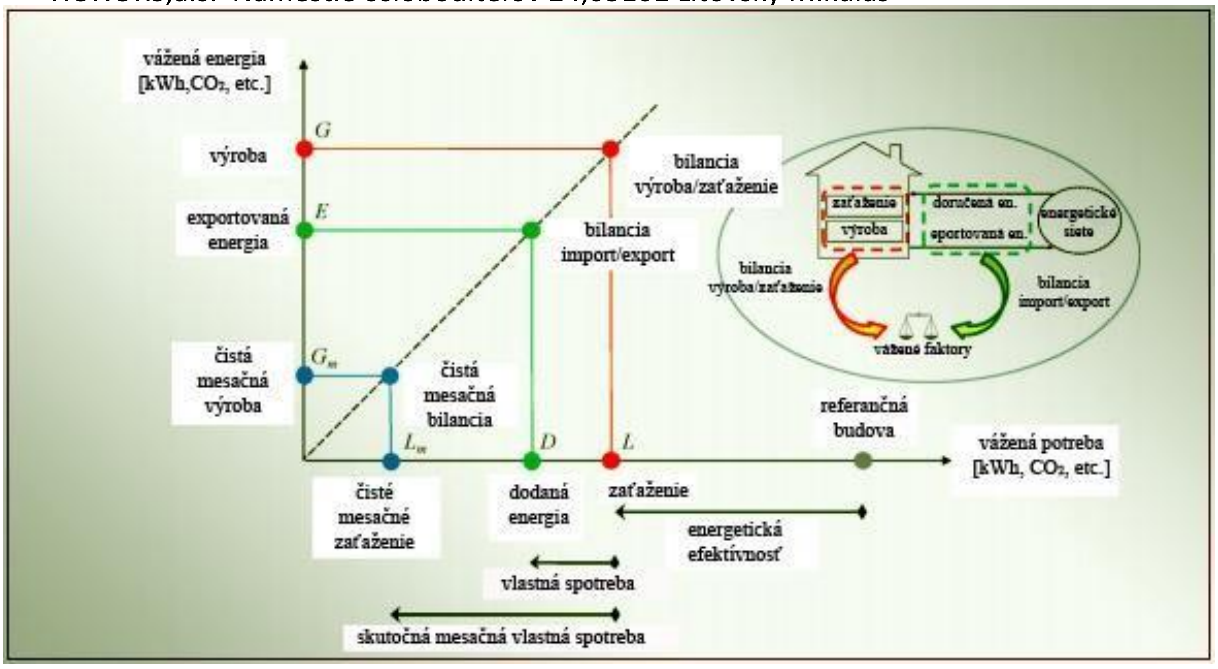
The boundary state of realisation of a building with zero energy needs is represented by the achievement of the state of zero balance at any moment. Then it is possible to talk about the island operation of a building. The remaining states of zero energy balances in the clearing point with the distribution energy systems include the unit of time that is usually a year or month. Also another technological progress brings the technologies that would help to fully supply the buildings by the energy without the necessity of connection to distribution networks within the standard economic conditions of the market and will be operated as the building in island operation. Buildings will be gradually equipped by the technologies providing the energy conversion of energy during individual stages of the transformation. The energy is supplied by local energy sources connected through interfaces into distribution energy networks. In case of buildings with zero energy needs it is necessary to set the weighting parameters in a very precise way. These parameters change the physical parameters that provide the realisation of economic models suitable for legislative process and therefore the social preferences, too. A consistent model of buildings with almost zero energy needs makes technical sense with the buildings with zero energy balance with distribution networks that we name by the term of Net Zero Energy Building (hereinafter Net ZEB). A building in island operation is called Zero Energy Building (hereinafter ZEB) (Sartori, I., et. all 2012) [7].

3.2.3 MODELS OF BALANCING BETWEEN ENERGY CONVERTED IN BUILDING AND ENERGY FROM DISTRIBUTION NETWORKS

All models of balancing in the clearing point between the system boundary of a building and the distribution networks for the state of zero balance satisfy the relation:

$$\text{State of zero balance} = |\text{supply}| - |\text{consumption}| \qquad (1)$$

The use of absolute values excludes the exchange within deciding whether the supply by local energy sources or the energy consumption supplied by distribution energy networks is understood with a positive and negative sign. In some cases, economic models do no provide the chance to express physical parameters in a direct way during balancing. Similarly, there are the cases when it is socially desirable to form the preferences for chosen energy sources. In both cases, the physical, eventually technical parameters are transformed through weighting parameters into weighting parameters that modify the values of physical parameters or have so called a coordinating function. We can use the calculation as an example of such a coordinating procedure



Picture no 6 Graphical representations of three types of balancing: balance of supplied and consumed energy, balance of given output and burden and balance of given output and burden per a month.

Factors of CO2 emissions for the electricity supplied through the distribution networks where the factor K is set from the share of different energy sources and the volume of released CO2 emissions within the supply of an electricity unit. The value of set factor of CO2 emissions for the biomass is in conflict with the physical parameter. Therefore the expression of the equation (1) by the means of weighting parameters represents a general relation that can be used for all clearing models.

A basic approach for the clearance of supplied and consumed energy represents clearance on the annual basis for every energy carrier separately. Clearance can be done on the basis of energy units.

There is a qualitative difference among energy carriers in the form of electricity, heat and cold. It is manifested not only by technical parameters. There is also a difference in economic costs invested for the energy conversion. ***Therefore it is suitable to solve clearance separately on the base of individual energy forms as a higher level of energy clearance or its generalisation as the balance of primary energy sources.*** The primary energies from the local energy source consumed in the building do not enter the balance in the clearing system of primary energies. Only the primary energy sources of local energy source enter the balance. They are supplied into the distribution network. Primary energy sources necessary for providing the supply are delivered from distribution networks to the building.

Except of energies we can do the clearing with the second utility value, too. It is the CO2 emission production. The clearing mechanism should be used for this parameter on annual basis. This parameter characterizes the ecological state of solution.

If the dynamics of the energy exchange between local renewable energy source and distribution network is high, for example within solar power plants, the building appears to be the energy source with variable energy output. The character of the building as an appliance changes into the character typical for energy sources and it is necessary to watch also the provided output or energy burden within total energy. Because of this reason, it necessary to add the basic definition by a solution that includes the balance of energy output whether it is on the hourly base, monthly base or annual settlement. The examples of three clearing systems are in the picture no 6.

Annual energy clearing represents the static approach to the issue and describes the building rather within its original mission. If we focus on the dynamic parameters, then we assess the energy burden that a building put on the distribution networks and on the other side the supplied energy output that the building provide into distribution networks. Within this approach we assess the building as the energy source with all its characteristics. Local energy sources of renewable type in the position of buildings are represented by energy sources with low energy output. If their number is small they do not represent any problem from the point of view of the system regulation. Their gradual numerous and performance expansion in distribution networks will cause the problem with regulation, because the immediate output of renewable energy sources supplied to the distribution network can far exceed the need and vice versa. A consequence is the problem related to the energy storage. It will require the complex solution of the regulation and ensuring that the supplies from local renewable energy sources are realized in accordance to the fulfilment of other quality indicators, too, whether directly or by the means of clearance by way of trade. Also because of this reason, we accede to the issue of clearance similarly like to a typical energy sources connected to the distribution energy network on the basis of the energy feed-in tariffs whether those that are set by the market or set by a regulator, where the energy price represents the social value of balance in a more complex way.

"Smart grid" is a concept for distribution networks that will be able to perform the measuring and power regulation of a big amount of small energy sources distributed around the distribution network providing the output that is regulated in relation to the requirements on the side of the consumption with the option of optimisation of the time of energy consumption via the active management of energy consumption in coordination with a consumer. A part of the solution is economic incentives for a consumer from the point of view of time optimisation in relation to the supplied output. The original idea of the significant savings of the energy consumption on the side of a consumer by the means of optimisation of power burden of appliances to the time of lower burden of the energy network is nowadays on the base of real experiments modified so that by a better organisation of appliances burden we can gain the savings of 1.5% on the side of a consumer. It is a small saving in comparison to the solutions and contributions of local renewable energy sources. For comparison, in case of the heat by the exchange of energy source by local renewable energy source we can gain the economic operational savings of up to 50%. The achievement of the quality of distribution network „smart grid" is a necessary condition, if the distribution network should be rebuilt in order to provide continuous energy supply on the market through the system of big amount of small local energy sources. It represents technical and economic assumption for the effective regulation and clearance of big amount of energy sources with small energy output.

Economic criteria determine if it is appropriate to provide the reduction of energy consumption by the means of the measures by the application of the technologies ensuring the energy efficiency expressed by the energy consumption for a unit area per a year within meeting and increase of the quality of internal environment. It is necessary to study the economic parameters such as an economic breaking point and the time of investment return related to the realisation of a relative measure. After exhaustion of the option of energy efficiency in terms of economic criteria, it is rational to adopt the change of energy source of a relative energy carrier. It is done in order to realize the investments into technologies designed for the conversion of the energies from local renewable sources as technically and economically optimal in relation to the need.

We can gain the state of zero balance between the building and distribution network by supplying enough energy from the local renewable energy source into distribution energy network. If we set too strict criteria in the form of physical parameters on the energy efficiency of a building, it can provoke increased investment costs into technologies of envelope structures that will not reach the economic breaking point and will be investment-inefficient. On the contrary, the investment and operational costs on the construction of local renewable energy source can have such technical parameters that even a higher level of the energy supply in the distribution network with the aim of gaining the state of zero balance will be economically justified. Technical and economic conditions for a concrete building and a concrete local renewable energy source are specific in a relevant location. We can gain a suitable technical solution with the investment return by their combination. The place of the sharp limit is a place that strictly determines the individual criterion of the energy efficiency for buildings with different construction and the purpose of the operation. It is more practical to set the interval in the form of the energy consumption per a unit of area per a year that enables the investor to select the optimal mix of technologies providing the energy efficiency and the technologies related to the conversion of a relative local renewable energy source into the required energy carrier while meeting the criterion of investment return. It is the economic motivation for an owner of local energy source to supply the distribution energy network by the maximum energy and thus maximize his profit. It is necessary to ensure in the legislation the non-discriminative approach of energy sources into the distribution network as a system assumption for the achievement of the minimisation of social costs and therefore the prices, too. We can transform this way the administrative way of the management of the buildings transformation as a part of energy market into the system with market economic motivation.

3.2.4 STAGES FOR MODEL OF ENERGY TRANSFORMATION OF BUILDING

The focused solution of the transformation of a building into a building with zero energy balance is divided into 4 basic stages that are appropriately designed within content for each energy carrier independently. The individual stages include:

- 1st stage - includes the solution of energy efficiency of building
- 2nd stage - includes the transformation of energy heat source from supplying the energy from the incineration of fossil fuels into supplying from the local hydrothermal energy source
- 3rd stage - includes the change of the quality of internal environment and expanding of the range of services by the supply of the cold
- 4th stage - includes the energy supply from the local hydrothermal energy source into the distribution network of the heat with the aim of achievement of the state of zero energy balance. The local source of solar electrical energy is constructed in this stage.

The development of available technologies verified by the market is different for the heat, cold and electricity. The correct accruals of their continual implementation enable to minimize the costs and provide the adequate investment return. The criterion of the investment into technologies determined for the solution of energy effectiveness represents a selected zone of investment return under the economic breaking point. ***There are two economic sources that are the result of made investments:***

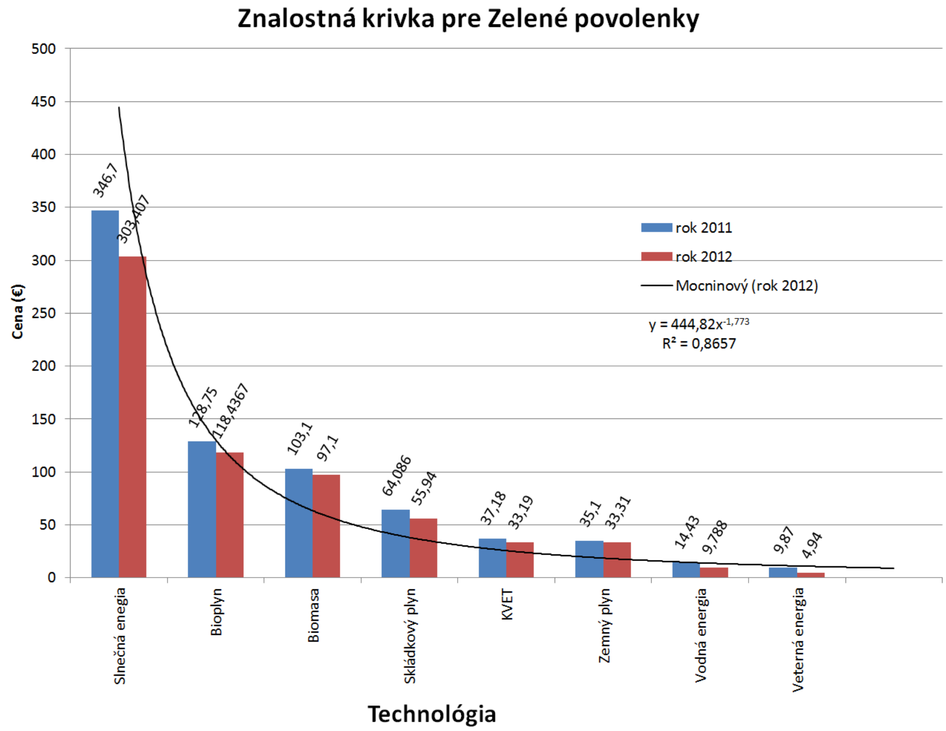
- ***energy savings***
- ***expansion of the range of services***

If there is the expansion of service in the form of quality rise of internal environment, the competitiveness of the building increases on the market. It has the impact on the preservation and rise of economic incomes and therefore on the creation of economic added value. Within the system design of the selection of modern technologies that serve to provide the energy efficiency of buildings, it should include also the fact whether the local renewable sources will be used or not. The reason lies in the fact that it is possible to combine the chosen technologies so that the effects of mutually supporting technical parameters are reached. In effect it leads to lower investment costs and faster return of investment vehicles. The synergistic effects reducing the energy consumption of the buildings are supported by a suitable selection of a technology as well as by the quality rise of internal environment necessary for the solution of the issue of heat waves as the impact of climate changes.

Solar energy and hydrothermal energy were selected for the transformation of the studied office building from the available local renewable energy sources in the system boundary of a building. The corresponding technologies of the heat pump water-water, radiant ceiling heating and cooling system and the systems of photovoltaic panels were chosen in relation to this energy mix. The time of their implementation was set, too. ***In 2008 the local hydrothermal energy source was put into operation in order to provide the heat and the cold. Solar power plant with the output of 200 kWh is planned with the targeted solution set for the period 2016-2020 according to the state of the technologies of photovoltaic cells on the energy market.***

3.3 SELECTION OF PRIMARY ENERGY SOURCES AND CORRESPONDING TECHNOLOGIES FOR CONVERSION OF ENERGY

The concept of the energy from renewable sources includes the energies from renewable non-fossil source that can be subsequently divided into the energies whose energy output for the needs of human economic activity is provided by natural ecosystems without additional production of CO2 emissions and the energy sources that are generated as the secondary product of human economic activity and their energy output is achieved by the incineration with the simultaneous production of CO2 emissions. The first category includes wind, solar, aero thermal, geothermal and hydrothermal energy, the energy of ocean and water energy. The second category includes biomass, landfill gas, gas from sewage treatment and biogases. The economic difference between these two categories of energy sources is visible in the fact that from the moment of payment of the used technology of the first group, the energy source brings efficient above average profit during the remaining lifetime of the technology that can be 60% to 70% of the total lifetime. Within the second group of energy sources it is necessary to always use human work, what causes the rise of the costs at least along with the inflation. If there are conditions on the market that support the demand rise, the price of raw materials for energy of biomass of biogas increases and therefore the costs, too. Moreover, in the cities there is not a suitable environment for the generation of energy sources of the second group due to the CO2 emissions formation, gradient of solid particles and often unpleasant odour. A state with the aim of the support of the technologies related to the renewable energy sources decided to follow the way of selective supplements for individual technologies and pay a fuel type to the price to investors. If a consumer does not purchase the technology or a part of it, but the utility value on the market, the energy and emission permits are supplied if the supplied energy is not accompanied by CO2 emission production. In order to decide what technologies are perspective within the current organisation of social preferences in achievement of economic clearing point, we have to ask the question: „ how much of additional costs must the society invest in order to supply the market by the energy avoiding the accompanying production of CO2 emissions, calculated per 1 to of CO2 emissions?“ The calculation of additional costs on the basis of the support realized through the transfers on the market for individual technologies separately, enable to construct the knowledge curve of additional costs of technologies and on the basis of individual steps changes determine the tendencies in accordance with the criteria of qualitative and quantitative knowledge curve.



Picture no 7 The knowledge curve for the technologies of renewable sources of energy and combined production of energy and heat calculated from the amount of supplements to the price of the energy on the market. (from left to right side: photovoltaic, biofuel, landfill gas, combined heat and power, natural gas, hydroenergy, wind energy)

The knowledge curve for green permits achieved from the technologies determined for the supply of the market by the electricity with quite a high level of reliability describes the qualitative knowledge curve and enables to determine that the technologies above 65€/t are the technologies that do not meet the criterion of lower costs than the social costs of CO2 emissions related to their discharge to the atmosphere. After the examination of the tendencies of energy audits from 2004-2011, i.e. during 8 years, we can see that the investment costs related to the biomass as well as the price of biomass rose by approximately 100%, circa 4 times more than the inflation. Therefore, without the change in law we cannot expect
an effective pressure on the costs reduction and thus the consumers' price of biomass in the horizon of 10 years that are governed by the law. It is generally true for the whole group of non-fossil energy sources where the energy is gained by the incineration and where the CO2 emissions are produced, too. The fossil fuels are burned in the technologies of Combined Heat and Power Production and of natural gas. They produce CO2 emissions. It represents an increased economic cost. Therefore, we should think about solar and geothermal energy as a suitable local renewable energy source. Since there was no supply by the electricity achieved from the geothermal energy on the market in 2011 and 2012, this type is not shown in the knowledge curve similarly to the energy of ocean or aero thermal energy.
The selection was oriented to renewable energy sources whose energy output in the locality of buildings is provided by natural ecosystem and technologies enable to perform the conversion in sense of the requirements of real time of economic process of energy supply to the building

for the purpose of heating in winter heating season, cooling in the summer season and electricity supply. It is the geothermal energy of the water from the well destined for the supply of the building by the heat and the cold and solar energy destined for the supply by electricity.

3.3.1 PRIMARY ENERGY SOURCE – HYDROTHERMAL ENERGY OF ENVIRONMENT

Requirements for heat and cold of the office building

- Heat:
  a. energy loss during the heating season: 278,000 kWh b. requirement for maximum performance of energy source: 125 kW
- Cold:
  a. energy loss during the summer period: 91,700 kWh
  b. requirement for the maximum performance of the energy source: 50 kW

Energy output and technical energy annual input of energy source of a well.

Energy potential of water source was measured by hydrologic test. Regarding the character of subsoil and construction below it, the test of sedimentation of particles showed that the ground motion is not detected up to richness of water source pumping 7l/s – 9l/s. The test for 7 days x 24 hours showed that seepage well is able to continually absorb such content of pumped water. The energy output of a well can be set in a following way for the purpose of heat supply:

- Yield of water supply: 7l/s – 9l/s
- Annual average water temperature: 13^0C
- Two water pumps connected in series
- Temperature drop of water from wells 4^0C for each heat pump
- Number of the days of heating: 204
- Number of the days of cooling: 153

Heat:

a. Maximum power output of a well for heat supply: 234 kW

b. The total energy input of a well per a heating season for the heat supply: /1000 = 1,147,713 kWh

Cold::

c. a. Maximum power output of a well for the supply of cold: 117 kW

d. The total energy input of a well during the summer season for the supply of cold: / 1000 = 430,392 kWh

Energy output of local renewable geothermal energy source is sufficient for the heating of the building in the winter season and for its cooling in the summer season. The technology of heat pumps water-water is suitable for providing the heat. Circulation pumps are efficient for cooling and the system of the regulation in the mode of passive cooling. A suitable combination of the operational mode of the technology of local renewable source for the summer and winter together with the suitable technology of end heaters and heat sinks enable to provide the heat and the cold in synergistic effects of the technology of heat pump and radiant ceiling system of heating and cooling. The technology of heat pump is a technology that was put into operation in 1928 in town hall in Geneva and it has undergone various technological improvements during 90 years since then. It is mass implemented in Germany, Sweden, Japan and Switzerland. The big running projects, e.g. in Denmark, are known with the total thermal output of 500 MWh. The heat pump of Waterkotte company, model DS

5017,5 AI overcame the value of COP 5 within the standardized conditions of measuring that are given by the conditions of B0/W35 as the first one in 2011. The technology of heat pump meets the criterion of the technology verified by the market, while the combined use of the technology of local energy source enable in the combination with the system of radiant ceiling heating to set the targeted solution of a year-round SPF=7 and separately at heat SPF%5 and at cold SPF=5. Once again, the ceiling system of radiant heating is known for a long time in the form of copper water distribution lines in the building ceiling that were constructed in 1950´s. Modern plastic systems can be considered to be other generations of technically verified system.

3.3.2 PRIMARY ENERGY SOURCE – SOLAR ENERGY

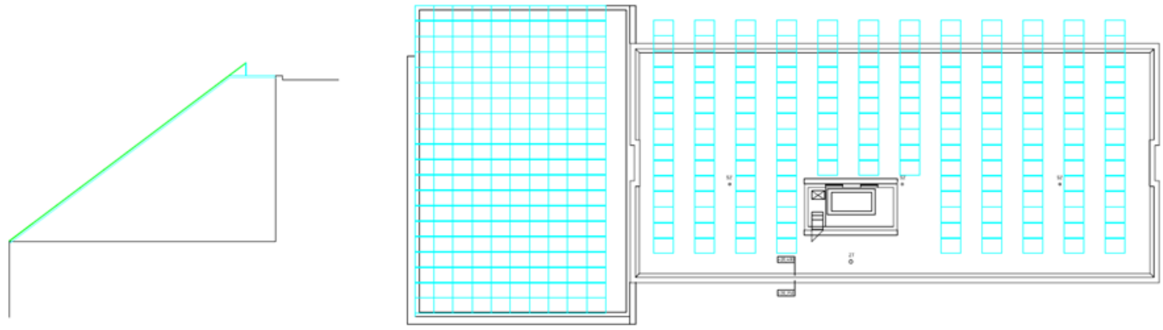
Requirements on annual supply of electricity for the building operation

- Requirement for energy output:
  a. Energy source of heat pump: input max.: 35 kW
  b. Other electronic appliances: input max. 60 kW, including lighting max. 30 kW
- Consumption of electricity necessary for the building operation:
  c. Energy source of the heat pump and the circulation pump: 106 MWh
  d. Electric lighting: 10.5 MWh, replacement for LED technology 3 to 4 MWh
  e. Other consumption of electricity necessary for the building operation: 8 MWh
  f. The total consumption of electricity necessary for the building operation is 124.5 MWh, after the implementation of LED technology the consumption of the electricity is 118 MWh
- Consumption of electricity necessary for the use of a building except of the building operation per year: 130 MWh

There is a large dispersion of the values achieved exclusively by the calculation or exclusively by measuring within setting the electricity consumption for the lighting. The reason is the way of the building operation and the behaviour of users. The modern measuring methods of electricity enable to eliminate these deficiencies with the sufficient accuracy and to determine the electricity consumption for the lighting during the year on the basis of actually measured values during a year-round operation of the building. For example, it also includes such rationalisation measures like the installation of motion sensors to lighting devices in the hallways, when consumption is heavily dependent on the movement of people along the corridors, which leads to a substantial reduction in energy consumption and so on. The value of the measured consumption of the electricity used for lighting of the building reached the value of 10.5MWh. In the future we think about the electricity consumption for the lighting after the replacement of lighting devices by the modern technologies of LED type on the level of 3 and 4 MWh per year.

Energy output and annual amount of the solar energy supply

The office building is constructed so that the Southern part of the façade creates the change for the construction of optimal area slope in order to place the panels in the angle of 37^0. The angle of 37^0 of placement placing can be also achieved on a flat roof. The Southern façade and the flat roof provide the space of total number of 365 panels with standard dimensions. We can consider the number of 400 pieces after the lift modification - picture no 8.



Picture no 8 A graphic representation of the solar panels distribution on the Southern façade and the flat root of the building. The view from the top and from the South.

The analysis of knowledge curve of photovoltaic cells and panels

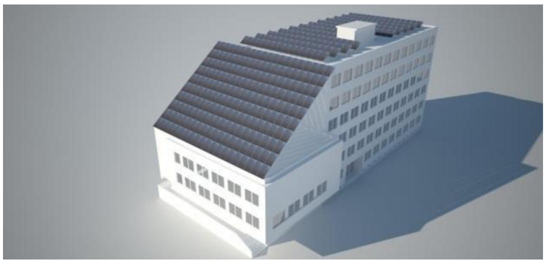
NREL Company analyses the development of the technologies of photovoltaic cells in its market analysis with photovoltaic panels and technologies of photovoltaic cells. It points to the fact that the efficiency achieved 43.5% (NREL, 2012) [5]. A significant increase in efficiency growth has been recorded since 1990. Nowadays, the mass production in the technologies of photovoltaic panels reaches the 19 and more % efficiency, while NREL expects the photovoltaic panels with the 40% efficiency by 2018- 2020. The investment return can be expected already by 2014 regarding the photovoltaic panels with the efficiency lower than 20-25%. Survey report of Deutche Bank announces the achievement of economic breaking point of photovoltaic systems already by the end of 2013 and in 2014.

The importance of renewable energy sources lies in the fact that the energies consume in the place of production and are eliminated the distribution losses in the extent of 15% in case of electricity. It requires the compliance with the qualitative parameters of electricity supply for the appliances. The instability of sunshine causes that it is necessary to ensure the effective balancing and accumulation system that would be able to store the electricity with the sufficient number of cycles for 8 to 12 hours and offer it for the consumption with adequate loss (up to 25%). The use of Nano-technologies as well as the systems based on the vanadium cells and biotechnologies indicates the promising results.

In relation to the electro mobiles realisation we can expect that this type of the vehicles starts to be massively implemented especially in the cities, while the charging of accumulators will be realized at the parking places during the working part of a day. So the batteries will produce an additional robust regulatory system and make the technologies in the synergistic effect cheaper. They are related to the electricity supply by the conversion of the energy from the Sun and wind.

Nowadays the last known problem related to the installation of solar power plants represents the issue of higher harmonious that occur in the surrounding of the installation and cause the damage of electronic devices especially those that are sensitive to the voltage stability. The electrical impulses up to the amount of 6,000V with the duration of 50µs can occur in the electricity network. The energy with frequent repetition of power peaks in the energetic network influences the electronic device and after the corresponding exposure by power peaks of higher harmonious causes its permanent damage. This issue has been known from the industrial disturbance in energetic network for some decades, especially in relation to the use of robots and therefore the studied issues are solvable by standard procedures.

The installations of solar power plants will be realized within 20 to 25 years. Therefore the expected technological progress within 4 to 7 years leads to the jump higher use of the area that is available. It also leads to the solution of the supplies quality into the networks through the accumulation systems set for 24 hour cycle. We can compare the demand on the energy output and the annual amount of the electricity supply of the building. By doing so we can come to the conclusion that it is economically convenient to wait with the investments. The area with the number of panels in the conditions of sunshine in the location of the building enable to install the photovoltaic panels with the energy output of 500 kWh in case of 40% efficiency of photovoltaic cells, with the total installation performance of 200 kWh with total annual energy production in the extent of 195 to 200 MWh. In addition to the solution of functional side of the power plant it is also necessary to emphasize the architecture of the solution so that the building would meet the criteria of urbanism and relative aesthetics of the solution after the construction of solar power plant. The architectural study of the building with the solar power plant - picture no 20.9.



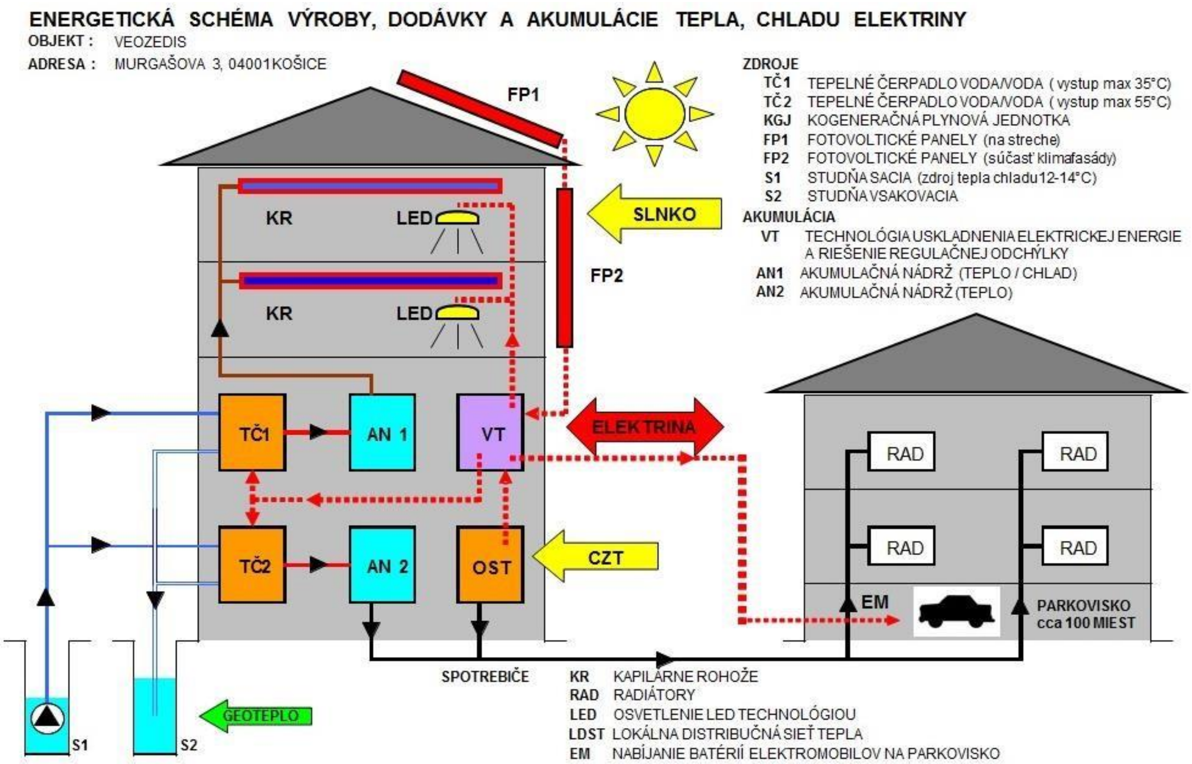

Picture no 9 The architectural study of the building in 3 Murgašova Street, Košice equipped by the solar power plant.

3.4 IMPLEMENTATION OF ENERGY TRANSFORMATION OF OFFICE BUILDING

With the above criteria the following technologies were selected for the transformation together with the relative years of the realisation:

1. The reconstruction of the discharge station of the central heating system in 1996
2. The exchange of the heating system for hot water for the building from a central type to a local type in 1996
3. The replacement of windows in the period of 2000-2005
4. The insulation of the building from 2000 to 2005
5. The installation of internal window aluminium blinds from 2000 to

2005
6. The hydraulic regulation of the heating in the building in 2005
7. The installation of a local energy source - a heat pump in 2008
8. The realisation of radiant ceiling heating and cooling system from 2012 to 2011; the improvement of the quality of internal environment and expansion of the services by cooling
9. The replacement of lighting devices and the implementation of motion sensors in 2012
10. The implementation of lighting LED bulbs - a plan for 2014-2015
11. The expansion of heat supplies from the local renewable energy source into the heat distribution network - a plan for 2014- 2015, according to the legislative conditions
12. The realisation of photovoltaic power plant with the output of 200 kWh with the annual supply of 200 MWh of electricity - a plan for 2018-2020



Picture no 10 the total energy scheme of the office building

A complex energetic scheme - picture no 20.10. includes also the construction of the parking place equipped by the charging stations for electric cars or cars with hybrid drive as a logical part of the whole complex of the building. The time estimate of the realisation of such parking place can be harmonized with the realisation of solar power plant as a subsequent investment. We can think about the effective investment around 2020 taking into account the development in car industry and especially the building of infrastructure by the state.

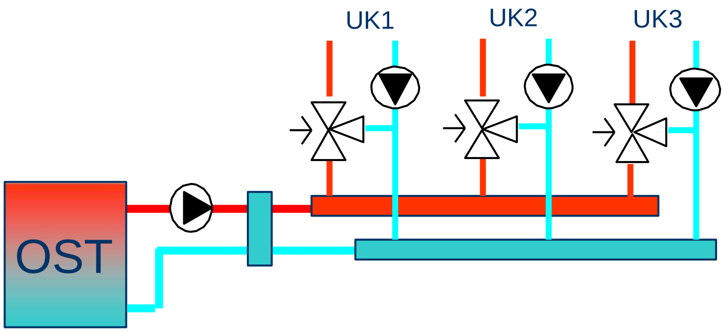
3.4.1 ADJUSTMENT OF HEAT SOURCE

The building was supplied by the heat from the discharge heat station till 1996, when it came to the end of its technical and moral lifetime. The discharge heat station was placed in the premises with the heat supply also for residential buildings standing close to it. The regulation of the temperature of heating water was the same for the residential buildings as for the office building. The heat supply had a low efficiency and it was not possible to keep the required parameters stable in the building. The building was often overheated without the chance of the realisation of setback mode during weekends or at night hours when there are no employees there. The reconstruction of the source was provided by a heat supplier. Original horizontal counter-tube heat exchangers were replaced by modern plate heat exchangers. At the same time, the regulatory nodes of heating were done for the Eastern (UK1) and Western (UK2) façade and the extension (UK3) - picture no 11. Each branch was given an option to regulate the temperature of heating water in the equithermic way by the means of three-way mixing valves and deployment of daily and weekend setbacks.

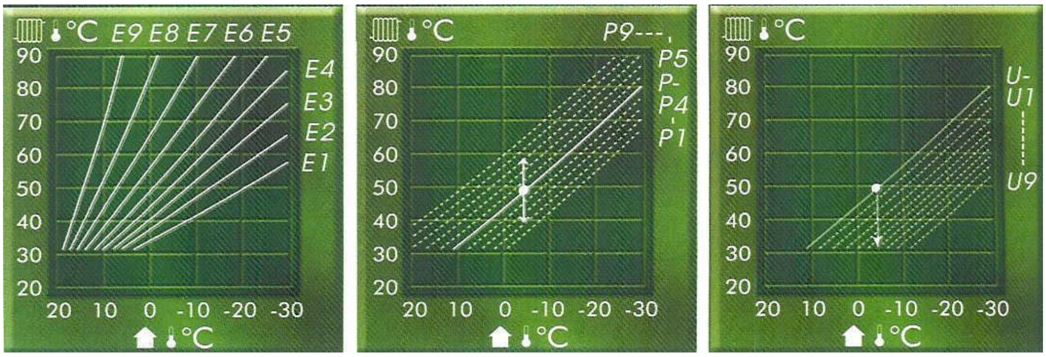
Chart no 1
Parameters of the object - adjustment of source, comparison

Parameters of the object	Year 1996	Year 1997	Units
The heat loss of the building	195	195	kW
The required heating water flow	16.8	16.8	kg/h
Temperature gradient of heating water	65/55	65/55	°C
Heat consumption for heating *	800	611	MWh
Heat consumption for water heating TV	88	No measuring	MWh
Total heat consumption ***	888	611	MWh
Heat savings during heating *	-	23.6	%

Note:
* In 1996 the heat consumption for the heating and hot water was measured together. The separation of the heat used for heating and for the hot water (HW) is determined by the technical calculation. The consumption for heating is actually measured in 1997.
** In 1996 the heat consumption for the hot water was calculated. In 1997 the water is locally prepared in flow electric heaters without measuring it. Therefore it is not shown in comparison in following years.
*** The heat consumption together in 1996 UK + HW. It was only the consumption on UK in 1997.
**** Heat consumption for heating is compared to the reference year 1996.



Picture no 11 The realisation of equithermic regulation of heating for each heated branch separately.



Equithermic curves   Parallel shift of the curve   Shifts of curve for setback mode

Picture no 12 A graphical example of heating curves and an option of the correction for setback modes of heating.

The dependence of the temperature of heating water on the temperature of external air is actually calculated according to a selected curve. An example of the way of calculation of a heating curve - picture no 12. The equitherming curve no E4 corresponds the building characteristics (influenced by heat loss, accumulation ability of the building and the characteristics of heating system). The required outlet temperature of heating water is 65°C at the temperature of air of -13°C. The temperature of heating water is calculated for other external temperatures of air. A parallel shift of the curve is not required. The curve shifts by the value U2 for setback mode at night or weekends. It means the decrease of the temperature of heating water, in the given case by 6°C.

The heat consumption within measuring is confirmed by the heat savings for the heating at the level of 23.6%. – Picture no 21 compared to the initial state from 1996.

3.4.2 CHANGE OF THE SYSTEM OF WATER HEATING

The method of heating and the supply of hot water depend on:

- A type of the object, volume and frequency of hot water consumption (HW)
- A source of heating and its suitability for the heating of HW
- Vastness of distribution and necessity of circulation pipe
- Necessity to do the disinfection by overheating the system against the emergence of Legionella bacteria.

The heating was originally realized in the hot water rank directly in the discharges station. The distribution lines realized by galvanized pipes were conducted into the spaces of sanitary facilities on each floor of the object. Supply points in the main building are centralized in two centres. Each of them has an independent riser pipe with circulation. The consumers are washbasin used mainly for washing hands. In the extension there are more sanitary facilities concentrated one above the other in two centres. The consumers are washbasins and sinks.

Hot water was originality supplied with the circulation in 1996. The distribution lines were insulated only by mineral felt with the thickness of 5mm. Such insufficient insulation and continuous circulation caused a high heat loss. It is reflected into a high energy demand for heating and supply of hot water. The calculated heat consumption for the heating of HW and power of circulation pump for 1996 is = 88 Mwah/year.

The heat needs is determined according to the calculations after the realisation of the transition of HW heating from the central type to the local one. The local heating means the disconnection of distribution lines of HW from the central source and the implementation of instantaneous electric heaters in the place of consumers (washbasins and sinks).

3.4.3 REPLACEMENT OF TRANSPARENT CONSTRUCTIONS OF WINDOWS AND INSULATION OF ENVELOPE STRUCTURES

The method of windows replacement and building insulation was designed into the stages so that a corresponding wall with replaced windows was insulated after the finalisation of the windows replacement on one wall of the building. After considering the fact that the envelope structures contain not only the fill of skeletons but also the insulation with the thickness of 5cm and subsequent layer of ceramic hollow glazed blocks - picture no3 and 4, the project documentation determined that the polystyrene insulation with the thickness of 8 cm is efficient. The complex insulating permeable system Baumit with the thermal insulator from polystyrene façade insulation boards was used for the realisation. The original windows were replaced by plastic windows with double glazing.

Chart no 2
Parameters of the object - insulation, comparison

Parameters of the object	Year 1997	1998-2004	Units
Building heat loss	195	135	kW
The required heating water flow	16.8	14.5	kg/h
Temperature gradient of heating water	65/55	58/50	°C
Heat consumption for heating	611	444	MWh
Heat savings during heating	-	27	%

3.4.4 HYDRAULIC REGULATION

Hydraulic regulation is a process focused on providing the redistribution of circulation medium transporting the energy from the source to supply points by the set of pipe distribution lines. We can use the assembly or fittings in the system to set the required the parameters. The conditions for the economy operation is the achievement of required parameters of internal environment, the elimination of heat gains and the minimisation of the costs needed for production and heat distribution. It also ensures the uptime without noise effects.

A hydraulic regulation ensures:

a. equal (required) heating in all heated spaces in relation to the type of space, way and time of operation,
b. elimination of heat gains that serves to avoid the overheating in the space and then saves the energy regarded the accumulation of building constructions and heating system,
c. hydraulic stability within the changing pressure conditions in the system,
d. the ability of a user to influence its consumption by controlled hot energy abstraction with the minimal impact on other consumers.

The regulation of necessary output (temperature) in the place that provides

a. a required size of radiator (current or new radiators are considered in the calculation)
b. required flow rates of heating water into a radiator (it is provided by the risers ‘valves and valves on radiators that are default in the project)

c. the temperature of heating water (provided by the SOURCE of HEAT on the basis of external temperature by the means of equithermic regulation with the time programme of heating operation)

d. water flow into a building (provides the SOURCE of HEAT on the basis of the project)

Consideration of heat gains in the room and required temperature

a. Installation of thermostatic head on the valve and setting to the required temperature Thermostatic head (TRH) is a regulator with the ability of setting the required air temperature in the place in the range of 5 – 26°C.
5°C – frost protection - if the valve is closed, it closes the water flow in a radiator; if there is a temperature drop, the valve closes and let the water enter the radiator and keep the temperature of the air at 5°C.
26°C – maximal allowable temperature of the air. If the temperature is lower than the set temperature of 26°C, the whole radiator heats, TRH fully opens the valve. If the temperature is higher than 26°C, TRH closes the valve and it does not heat. Even when TRH is fully opened at 26°C, this temperature does not have to be reached, because the water from the source is regulated in order to reach the max. 23-24°C. TRH does not produce the heat, only keeps it or reduces what is supplied from the source of heat.

b. A common operational state in the room is circa

20-22°C Example:
TRH set at the temperature of 20°C = I REQUIRE THE TEMPERATURE OF 20°C IN THE ROOM

- if the temperature in the room is 20°C and less, the whole radiator heats
- if the temperature in the room is 20-22°C, only a part of the radiator heats, e.g. the upper part
- if the temperature in the room is 22°C or more, the radiator does not heat

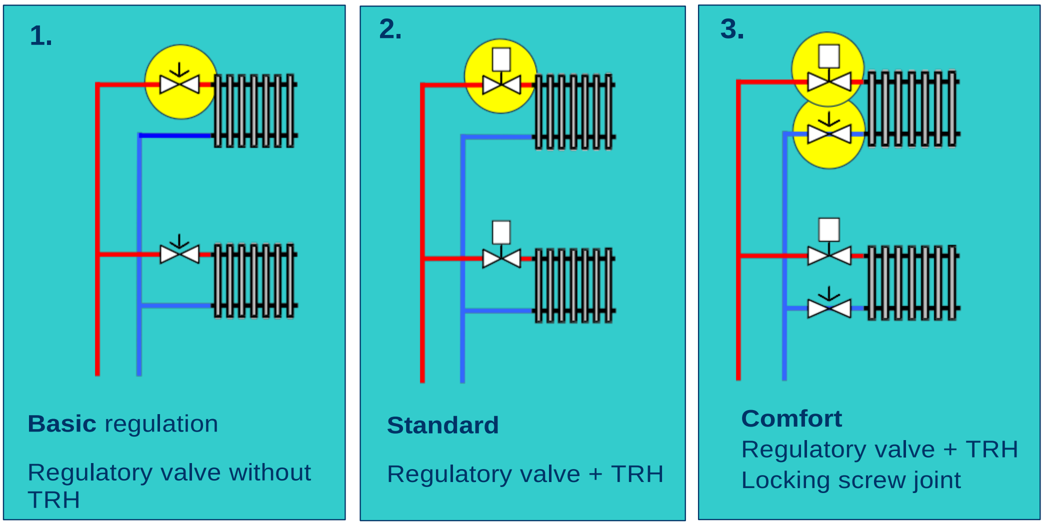
There can be an inaccuracy within the required temperature during the operation, if the TRH is influenced: covered by curtain, close to the source of heat that heats the head or incorrect position of the head (then TRH does not read the temperature in the room but the temperature of the surrounding that can have a different temperature)

The ways of regulation on heaters

1 Basic regulation - picture no 13 - 1
- regulatory radiator valve with pre-setting without thermostatic head
Uniform regulation in all rooms, elimination of overheating, the possibility of heater closure

2 Standard regulation - picture no 13 - 2
- thermostatic radiator valve with pre-setting
ditto 1+ elimination of heat gains, the possibility of pre-setting the required temperature

3 Comfort regulation - picture no 13 -
3
- thermostatic radiator valve with pre-setting + regulatory screwing
ditto 2 + possibility to assembly the heat during the operation, the reduction of noisiness on the valve (a part of pressure constricts the screwing)



Picture 13 The ways of regulation of heating systems on heaters. (TRH is thermostatic head fitted on the regulatory radiator valve).

The way no 3 is used on the radiators in the described building, according to the picture no 13

The ways of the regulation on the risers

The task of the regulation of horizontal distribution lines is to provide the required amount of heating water into risers

The regulation must take into account:

a. output of heaters that it supplies,
b. position of riser pipe (the orientation to the cardinal points, depends on the heaters,..)
c. a type and giveness of horizontal distribution of heating.

1 Basic regulation STATIC - picture no 14 - 2
- risers´ regulatory valve with pre-setting and option of measuring provides the required distribution of the heating medium into individual riser pipes by pre-setting of the valve. It enables the measuring (control) of flow. It does not provide the protection against the changing parameters.

2 Standard regulation DYNAMIC - picture no 14 - 3

- Ditto 1 + relief valve RV

ditto 1 + the elimination of increased differential pressure of rises pipe by releasing the flow, the reduction of noisiness on radiator valves, the reduction of the efficiency of distribution lines by increasing of the temperature of a return pipe

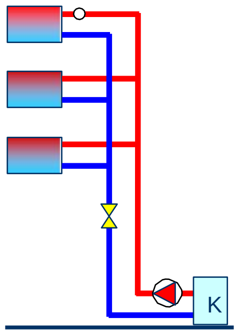
3 Comfort regulation DYNAMIC - picture no 14 - 4

- Ditto 1 + controller of differential pressure CFP connected by a capillary

ditto 1 + the elimination of increased differential pressure of rises pipe by constricting, the reduction of noisiness on radiator valves, the reduction of efficiency of distribution lines by increasing of the temperature of a return pipe

INAPPROPRIATE

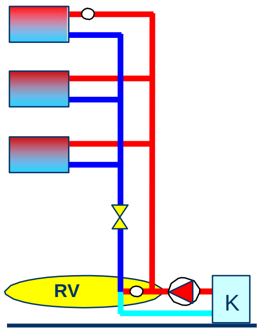
Y



WITHOUT THE ELIMINATION OF THE CHANGE OF DIFFERENTIAL PRESSURE

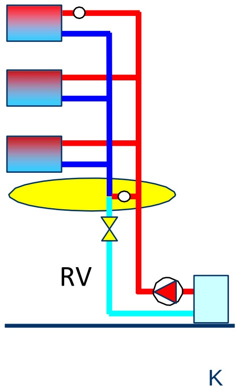
CONDITIONALL

APPROPRIATE



RELIEV VALVE AT THE ENTRANCE TO THE BUILDING

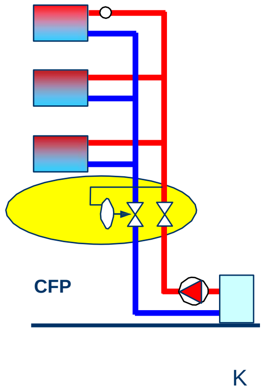
APPROPRIATE



RELIEF VALVE ON THE FOOT OF RISERS

APPROPRIATE

the best



REGULATOR OF DIFFERENTIAL PRESSURE

Picture 14 The ways of regulation of heating systems on risers

The system is realized on the foot of the risers in the building - picture 14 - variant "4", regulator of differential pressure.

Benefit of hydraulic regulation

- removal of overheated and under heated rooms
- option of individual regulation of each heater
- minimisation of the consumption of circulating heating water = the reduction of pumping
- together with the equithermic regulation of heat sources, the minimisation of energy consumption for heating. The measured savings in operation on the heat supply represent 15% (a difference between 2002 and 2005 - picture no 21.

3.4.5 REPLACEMENT OF HEAT SOURCE

The above mentioned modifications were focused on the improvement of energy efficiency, i.e. the reduction of heat consumption for the heating of the building, its optimal production and supply.

The modifications were realized in these areas

- construction part = improving the thermal-insulating characteristics of the building, especially the envelope structures
- modification of a heat source = the realisation of the optimisation of heat supplies by the management of the heat source using the setbacks of heating
- modification of the system of heat supply = uniform heat supply into the heaters with the option of heat gains elimination by the means of hydraulic regulation and the implementation of thermostatic heads

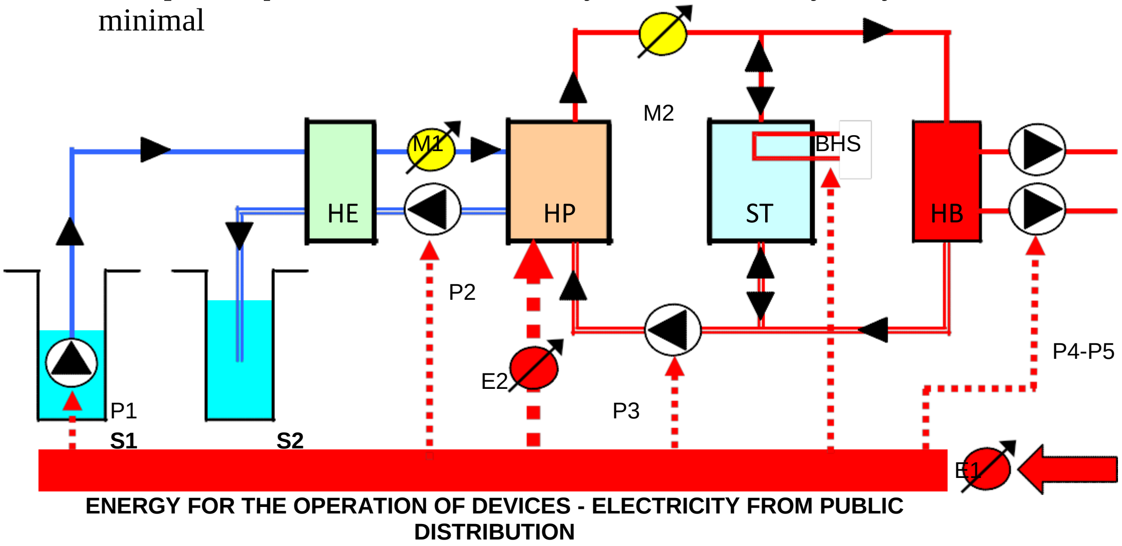
Technical possibilities of the technologies that provide the energy efficiency and are economically justified have been exhausted. Another reduction of primary energy sources and CO_2 emissions production within the preservation or improvement of internal climate was realized by the modification of heat source that will reduce the operational costs on the supplying of the building by the heat using local renewable energy sources available in the place of heat consumption.

After the technical-economic balances we confirmed the design of the realisation of the alternative heat source - a heat pump with the primary energy from renewable source of underground water.

The features of the building and its technical characteristics enabled this alternative.

- in the building there is a dug well with the water capacity of 12l/s
- the realisation of absorbing tanks is simple and economical undemanding in the space of building
.
- The building is insulated and hydraulically regulated; it decreases the output requirement on the heat source
- Because of the insulation, the current heating system with radiators is operated In reduced temperature zone of 58/50°C. It enables the application of the heat pump

- Space requirements are satisfactory and the necessity of system modifications is minimal



KEY:

HE HEAT EXCHANGER
HP HEAT PUMP WATER/WATER
M1-2 HEAT METER
E1-2 ELECTROMER
ST STORAGE TANK OF HEAT
HB HEATED BUILDING
BHS BIVALENT / BACKUP HEAT SOURCE
S1-2 SOURCE SUCTION WELL/ RECHARGE WELL
HE HEAT EXCHANGER
P1 PRESSURE PUMP IN WELL
P2-3 CIRCULATION PUMPS - MACHINE ROOM
P4-5 CIRCULATION PUMPS - OBJECT

Picture no 15 the scheme of the connection of a heat pump water/water in the system of the transformation for the heating by radiators in bivalent connection in the office building.

The stages of the realisation of renewable energy source

- Preparatory phase
  - Technical-economic study confirming the convenience of the application of Heat source
  - Defining the conditions of the connection to electrical system with the supplier of electricity (the possibility of consumption and attribution of favourable electricity tariffs) like the driving power for the system operation with a heat pump
  - Defining of conditions of connection of bivalent source (current discharge station the building that supplied the building with the heat) if there is not satisfactory output of the heat pump or as a backup in case of failure
  - Construction of seepage tanks and hydro-geological assessment of yield of pumped well and flow rate of seepage tanks - project phase
  - processing of energy balances
  - selection of a suitable type and size of a heat pump
  - independently assessed parameters were reliability parameters, lifetime parameters and the way of monitoring of these parameters by a producer
  - processing of project documentation
- realisation of renewable source
  - realisation of machine room with a heat pump
  - connection of all related media (water, electricity, heating distribution lines)
  - realisation of the system of measuring and control of the activity of the source with HP
  - putting the source into operation
- operation and assessment
  - a design and installation of measuring equipment for individual system elements with a HP
  - assessment of measured data
  - optimisation of operation = corrections in the process of regulation, technical adjustments for the purpose of improvement of total operational efficiency and prolongation of the lifetime of the machine room equipment with a heat pump
  - realisation of regular operational controls of equipment and maintenance

Chart no 3
Technical parameters of the machinery room with HP

Climatic conditions:	
Place:	Košice
Average external temperature in heating period:	+3.0 °C
Regional design temperature:	-12 °C

Altitude:	220 m asl.
The number of days in heating period:	225 days

Chart no 4
Technical parameter of applied heat pump

Thermal pump Waterkotte 5136.3		
Heat output at 0°/35°C: **95.3 kW**	Electric input: **24.8**	Coefficient of performance
Heat output at 0°/50°C: **97.7 kW**	Electric input: **28.5**	Coefficient of performance
Refrigerant: ecological refrigerant R 407 C		
Compressor: Waterkotte, the number of switching cycles 66,000 to 90,000; mean time between failures		

3.4.6 REPLACEMENT OF EXCHANGER SYSTEM FOR HEATING/COOLING

The idea about the modification of heating system followed from the requirements:

- to increase the efficiency of heat production by the means of heat pump
- to create the preconditions for the implementation of new technologies of end heating and cooling micro-capillary systems
- to heat by the system more favourable for the human physiology and therefore increase the quality of the internal environment of the building
- to use the energy potential of the well even for the option of passive cooling
- to significantly reduce the parallel production of CO_2 emissions
- to reduce the operational costs connected to the operation of heating and cooling
- to create the conditions for the realisation of solar power plant with the option of the realisation of a building with zero energy balance with distribution networks
- to create the conditions for metering the energy from the heat pump to the balance of a country monitored by the EU

The description of radiant ceiling system of heating/cooling

A fundamental difference to the conventional heating system is in the way of transfer of the heat and the cold. It is the large-scale low-temperature radiant heating with the option of "high temperature" cooling. The system consists of distribution pipes of small diameter of 3-12 mm with appropriate spacing according to type on the area that forms the heating / cooling element. It can be installed either as a part of ceiling construction when the pipes are refused or in the soffit below the ceiling. The soffit makes possible to use the solution with ceiling tiles or the arrangement of the pipes on the drywall ceiling. The way of the application of the pipes influences the heating and cooling output, the way of conduction of connecting pipes and the way of regulation and design. A dry capillary matting system was chosen in the described building that was reconstructed in full operation. It is placed in the soffits from perforated sheet cassettes.

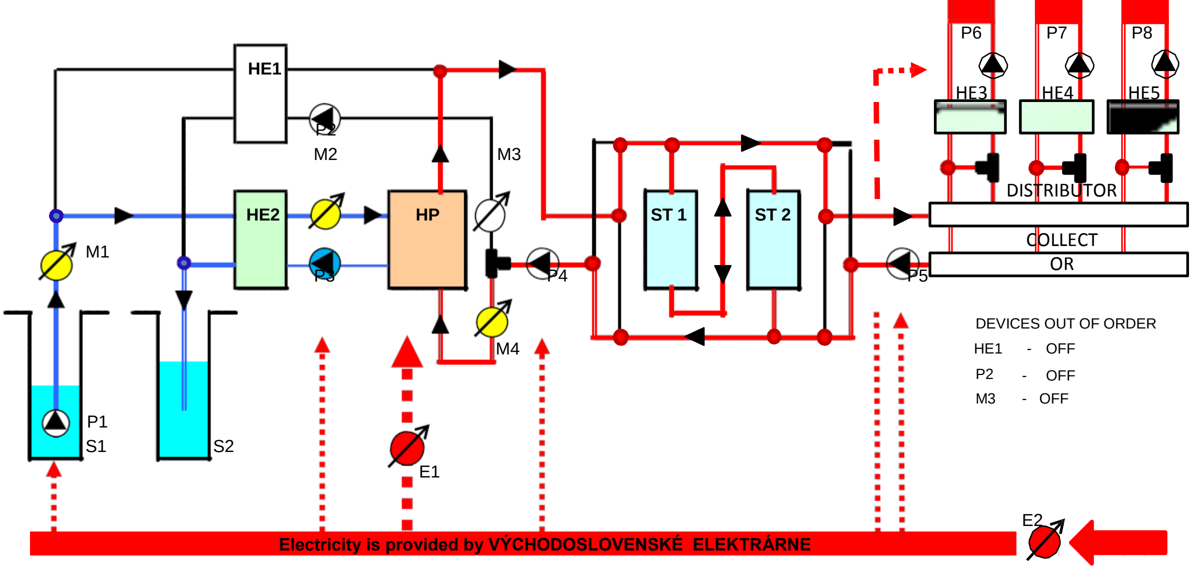
The heat supplies the space by radiation. The radiation affects the surfaces, especially floors and the equipment of the room. Then, the air is heated from the heated surfaces. In case of cooling, the cold is again provided by radiation. In both cases, the heat supply happens at minimal air circulation without air current. Air venting is usually provided by infiltration and natural ventilation through windows. If there is a demand for higher intensity of venting, it is possible to transport the air to the false ceiling (if the capillary mattings are installed in the soffit) and the air can be supplied through the holes in the soffit (so called perforated ceiling without diffusers). In combination with ventilation it is positive that cooling respectively heating output is provided by the radiant system and the ventilation is not limited to the intake of ventilation air. It significantly reduces the demands for the dimensions of the pipes, size of ventilation units and the ventilators performance.

Adjustments in the machine room after the installation of ceiling system

The application of the system of ceiling heating/cooling required the adjustment in the machine room as there were differences in the previous system of supply of the heat to the radiators. Original heating by radiators - picture no 15 and the designated system of ceiling heating/cooling - picture 16 and 17. The devices that were added:

- A heat exchanger HE2 for the cold off take from the well water
- Addition of another accumulation tank into series in order to reduce the number of switches of heat pump and suction pump in the well
- Interconnection of heat storages that provide the option of charging and discharging in the heating mode from the top, in the cooling mode from the bottom. A different mode from the top/bottom requires the layering of the water in the tank according to the temperature
- Installation of separating heat exchangers HE3, HE4, HE5 due to the used capillary mattings in the ceiling from other metal distribution pipes. The lack of oxygen barrier in plastic distribution pipes causes the diffusion of oxygen through the walls of the pipes that can cause the corrosion of metal pipes and equipment in the system.

SCHEME OF PRODUCTION AND COLD SUPPLY

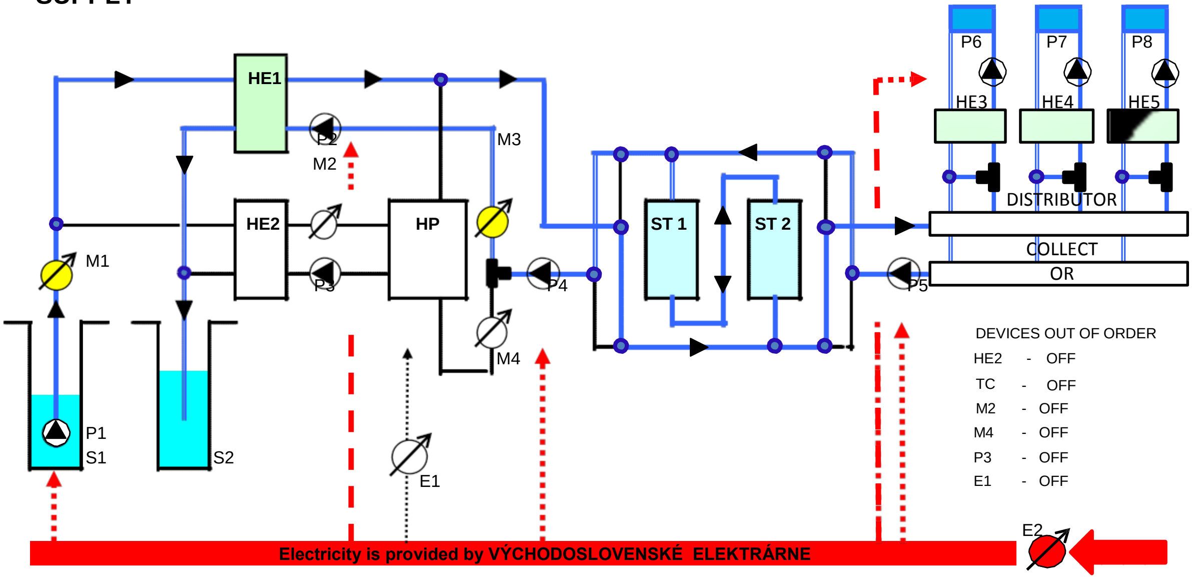


KEY:

HP	HEAT PUMP WATER/WATER	P1	IMMERSION PUMP	H1-3	HEATED BRANCHES (30/28°C)
VSE	ELECTRICAL SYSTEM VSE	P2-8	CIRCULATION PUMP	M1	WATER METER (TRANSFERRED
S1	SOURCE SUCTION WELL	HE1-5	HEAT EXCHANGERS	M2-4	METER OF HEAT/COLD
S2	SUCTION WELL	ST1,2	STORAGE TANK	E1,2	ELECTROMETER

Picture no 16 The scheme of the connection of a heat pump water/water in the system of the transformation for the supply of the office building. The adjustment of the machine room of the energy source for the application of the radiant system of heating and cooling. The principle of the heating operation.

SCHEME OF PRODUCTION AND COLD SUPPLY



KEY:

HP	HEAT PUMP WATER/WATER	P1	IMMERSION PUMP	H1-3	COOLED BRANCHES (18/20°C)
VSE	ELECTRICAL SYSTEM VSE	P2-8	CIRCULATION PUMP	M1	WATER METER (TRANSFERRED
S1	SOURCE SUCTION WELL	HE1-5	HEAT EXCHANGERS	M2-4	METER OF HEAT/COLD
S2	SUCTION WELL	ST1,2	STORAGE TANK	E1,2	ELECTROMETER

Picture no 17 the scheme of the connection of a heat pump water/water in the system of the transformation of the cold for the supply in office building. The principle of the cooling operation.

An important impact of radiant system has the temperature gradient of the heating medium (32/30°C) or cooling medium (18/20°C). The reduction of the thermal gradient from 57/50°C to 32/30°C enables to increase the source efficiency (COP) of the heat of the heat pump. Measured data from the operation of heating is confirmed by the values:

- Heating in the operation with radiators 57/50°C » (COP=3.9 SPF=3.1) - measured
- Heating in the operation with capillaries 32/30°C » (COP=5.5 SPF=4.1) - measured
- Passive cooling with capillaries 18/20°C » (EEF=11.2) - measured
- Active cooling with the SPLIT system for comparison » (EEF=cca2.7) - estimated

The increase of the value SPF by 32% occurred within heating in comparison to the systems with radiators. The EEF within cooling is circa 310% more than the common cooling split systems. From the point of view of transformation efficiency and heat/cold supply is this system one of the most effective methods that can be used in real conditions of buildings supply.

A heat pump or the support by solar system is suitable for the real operations. The efficiency of the source is markedly higher thanks to the low temperature of heating water in comparison to conventional heaters. Their temperature gradient is around 60/50°C. Cooling provides the medium temperature (17°– 20°C). Within such a "high" temperature of the medium, we can use the water from the well or the ground temperature as a source of cold, because their temperature is 15°C in the summer.

The crucial fact is that we do need to produce the cold, what reduces the costs on cooling only to the pumping work of the cold transport (= passive cooling). The amount of this work can be influenced by a suitable technical solution and a design of the system. Eventual removed heat from the cooling of the spaces can be transformed into the heating of hot water needed for the operation of the building.

3.4.7 QUALITY OF INTERNAL ENVIRONMENT AND HUMAN PHYSIOLOGY

In the combination with modern technologies the standard technologies that ensure the energy efficiency help to increase the quality of internal climate and they are also the answer to such phenomena like climate changes and related issue of thermal waves linked to the increased risk of organism collapse.

25,000 to 70,000 people died because of the heats from 2003 in the countries of the European Union ((Brücker, G., 2005)[3]. The calculations show that the thermal wave during the summer in 2010 caused the death of 55,000 people in Europe (Barriopedro, D., 2011). [2] Similarly, in Slovakia on 20th August 2012, 109 people collapsed, 26 of them from Košice region.

The analysis of the sample of 9 European cities with the total population of 25 million inhabitants in various places of Europe shows that there is a critical minimal night value and critical minimal day value that determine the beginning of the exposition of the environment to a heat wave. It is characterized by an increased risk of organism collapse resulting in death. The risk grow in the EU varies from 7.6% to 33.6% in the relation to the corresponding city(D´Ippoliti, D., et all 2010) [4]. A thermal wave is determined by the extreme daily temperature T_{app} given by a formula1 and the lowest night temperature T_{min}.

$$T_{app} = -2.653 + 0.994(T_{air}) + 0.0153 (T_{dewpt})^2 \quad T_{dewpt} \text{ is dew point temperature} \quad (20.2)$$

A thermal wave happens if:

1. T_{app} exceeds 90th percentile of monthly temperature distribution in the period of at least 2 days

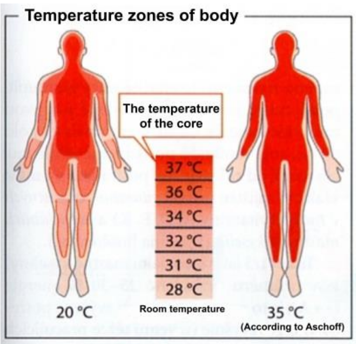
.

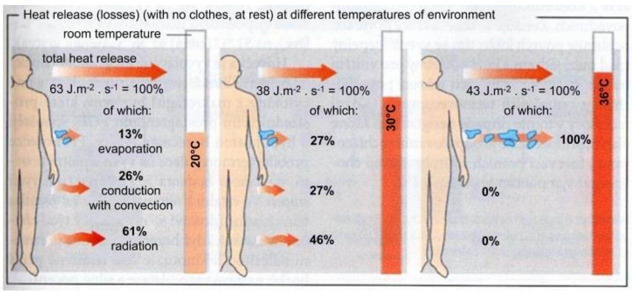
2. Tmin exceeds 90th percentile and T_{app} exceeds the median of monthly value

We can demonstrate on the example of thermal regulation of a man that a man represents autopoethic system and his biological body is not out of surrounding environment. The increased risk of organism collapse occurs when the surrounding temperature reaches the critical value during 48 and more hours. Then the conditions that are incompatible with the human existence can be formed, what causes the collapse of an organism from the heat and in an extreme case even the death.

Thermal regulation of a human organism keeps the temperature of the core at the level of 37˚C. The temperature goes down towards the outside and to the feet. The lowest temperature is on legs = 28˚C. The balance between the organism and the environment is kept by three mechanisms of the energy exchange. The decisive mechanism - two-thirds - is created by the mechanism of radiation at the external temperature of 20˚C. Mechanisms of conduction and convection form 26% share, the remaining part is evaporation. The share of the mechanisms of radiation and convection together with the conduction gradually weaken with the external temperature growth and they disappear at the temperature of 36 ˚C. At this temperature there is only the mechanism of evaporation available for an organism.

A body is able to keep its micro climate in the form of small air layer heated by human body at the air movement of < 0.1 m/s. The signals that are provided by peripheral thermo receptors of the skin into the centre of thermoregulation management in the hypothalamus provide correct information for the regulation of heat exchange. If the rate of airflow with the speed is above 0.1m/s, the flow of the air removes the micro climate from the body surface and the flowing air directly affects the thermo receptors placed in the top layer of skin. The body is not able to heat the micro climate on the places when the skin is continuously cooled by the airflow. On the other side, the cooled flowing air much slowly cools the building constructions and therefore their temperature is higher than the air temperature. Thus the component of the energy exchange by the radiation is significantly lower. The thermo receptors so provide misrepresented data about the temperature (lower) to the control centre of thermoregulation.



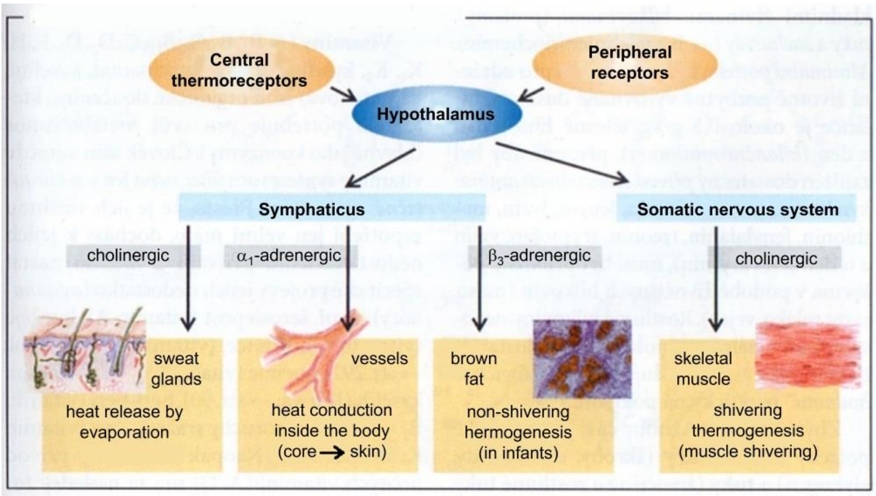


Picture no 18 and 19 Human thermal zones and energy transport mechanisms

The information from the peripheral thermo receptors creates the feedback of regulatory circuit that inform the centre of temperature control of the hypothalamus about the changes in the environment out of organism. The internal thermo receptors inform the control centre of the temperature about the actual state of the temperature of the core of an organism. This allows through sympathicus and somatic nervous system to actively manage the exchange of energy with the environment described above by energy transport mechanisms. Distorted information in case of cooling by the convection and the conduction lead to the fact that an organism keeps the heat in the body even if a person feels cold mediated by the peripheral thermo receptors of skin. The energy balance of human-internal environment does not happen. The result is that after the man leaves a building cooled with the air flow, he immediately sweats in the external environment.

The radiant system of energy transport firstly heats/cools the constructions and areas and then the surfaces heat/cool the air. Therefore the systems of radiant ceiling heating are suitable also for cooling, while they use a decisive element of energy transport in the human physiology. They improvement of the quality of internal climate in comparison to the radiators at heating and especially the split systems at cooling in a significant way, because they are able to comply with the requirement of thermal comfort for the parameter of the air ≤ than 0.1 m/s. The split systems are not able to comply with it in the principle. Similarly, the radiant ceiling system does not cause the reduction of relative air humidity what happens with split systems and radiators. On the contrary to the floor heating system that is rarely suitable also for partial cooling, the large-scale radiant ceiling heating systems are usable even for cooling if a carrier medium is a liquid up to the 4m height of the ceiling.

The use of large-scale radiant system of capillary matting for heating and cooling means the reduction of heating temperature that results in the growth of work efficiency of the heat pump and the shift of the factor SPF 3 for radiator to 4.5 within the heating and the chance of achievement SPF =14 within cooling. The target value of annual SPF factor 7 is a realistic expression of the possibilities of the combination with the heat pump water-water.



Picture no 20 Control of human thermoregulation

In order to provide the growth of the quality of social life in the relation to the climate changes it is possible to provide:

1. expansion of provided range of services by the cold
2. To provide the transport energy while respecting the human physiological characteristics
   in a decisive part by a radiant component
3. Synergistic effect of technical and ecological parameter is achieved using renewable geo-thermal energy source and a large-scale radiant ceiling heating system of end elements in the form of micro-capillary system.

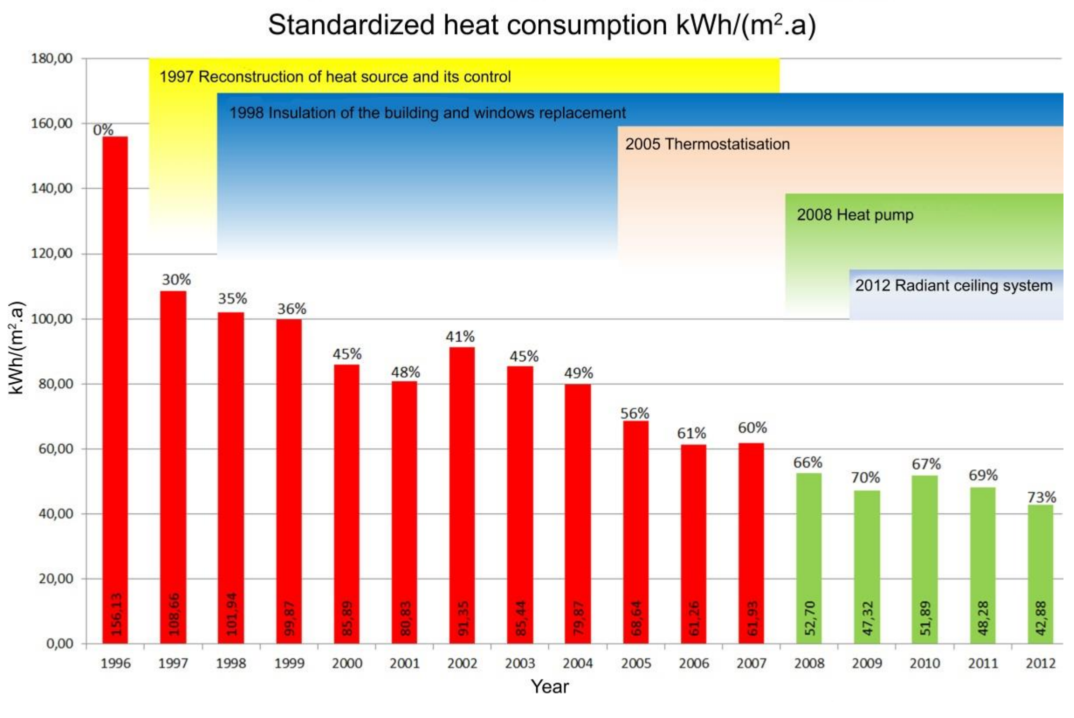
3.5 INTERPRETATION OF ENERGY TRANSFORMATION RESULTS OF OFFICE BUILDING

The executed experiments in the office building in 3 Murgašova Street, Košice demonstrate the technical and economic feasibility of the transformation of buildings into buildings with almost zero energy balance with distribution energy networks without the

interruption of service. Experimentally gained data also enable to interpret the physical parameters and correctly understand weighting parameters of social preferences expressed in the consistent form of a model of building with zero energy balance. The reference state of the building is the one from 1996 with corresponding parameters.
The system boundary of the building can be studied in the following logical connections of physical, economic and ecological parameters.

3.5.1 GROWTH OF PHYSICAL PARAMETERS OF ENVELOPE CONSTRUCTIONS

The application of the technologies of envelope structures of the building together with the technologies of energy management shows that we can achieve the savings at the level of 73% within the solution of energy efficiency of heat consumption. In such a case the primary energy in the form of electricity that is necessary for the drive of the heat pump is not included in the energy balance because the supplied energy for the heat pump drive does not pass the envelope structure in the form of heat, although the economic part of system boundary of the building passes. Consumed energy for the heat pump drive does not contribute on the heating of the building. The heat is calculated on the standardized consumption by the means of day degrees. The course of the heat consumption from 2002 to 2006 shows the necessity of the realisation of the hydraulic regulation that would eliminate the human factor on the side of heat supplier, who tries to realize the maximal supply even though there is not the need for it from the point of view of actual climate conditions.



Picture no 21 Standardized heat consumption in the office building

3.5.2 ECONOMIC PARAMETERS

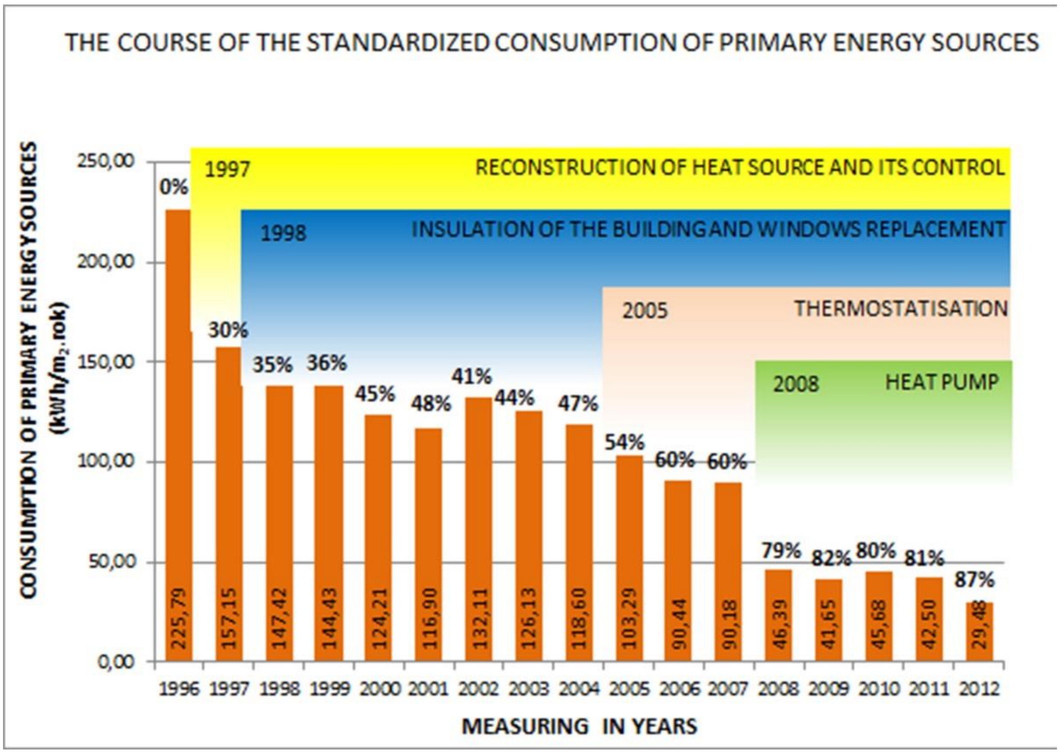
National economic level of solution is characterized by the gained level of savings of primary energy sources introduced through the system boundary of the building in the amount of 87%

reaching the consumption state of 29.4kWh/ (m^2.a) for the heat and 64kWh/ (m^2.a) together with other mandatory items of the energy consumption related to the operation of the building. In such a case the neglected primary energy of renewable energy sources is supplied by the heat pump because this part of energy do not pass the economic part of system boundary of the building and do not enter the economic costs. It will last till the state imposes the tax on the energy removed from the well water.

Chart
no 5
Energy balance of office building in 2012

Consumption of primary energy sources in the office building in 3 Murgašova Street, Košice		
	kWh(m2.a)	kWh/year
Electricity consumption for the heat production	10.67	57301.02
Electricity consumption for the cold	1.94	10443.1
Electricity consumption for heating the hot water	0.56	3,000
Electricity consumption for lighting	2.79	15,000
Electricity consumption for circulation pumps of building and distribution of heat and cold	7.19	38,606.59
Total electricity consumption in building	23.15	124,350.7
Total consumption of primary energy sources	63.98	343,705.4

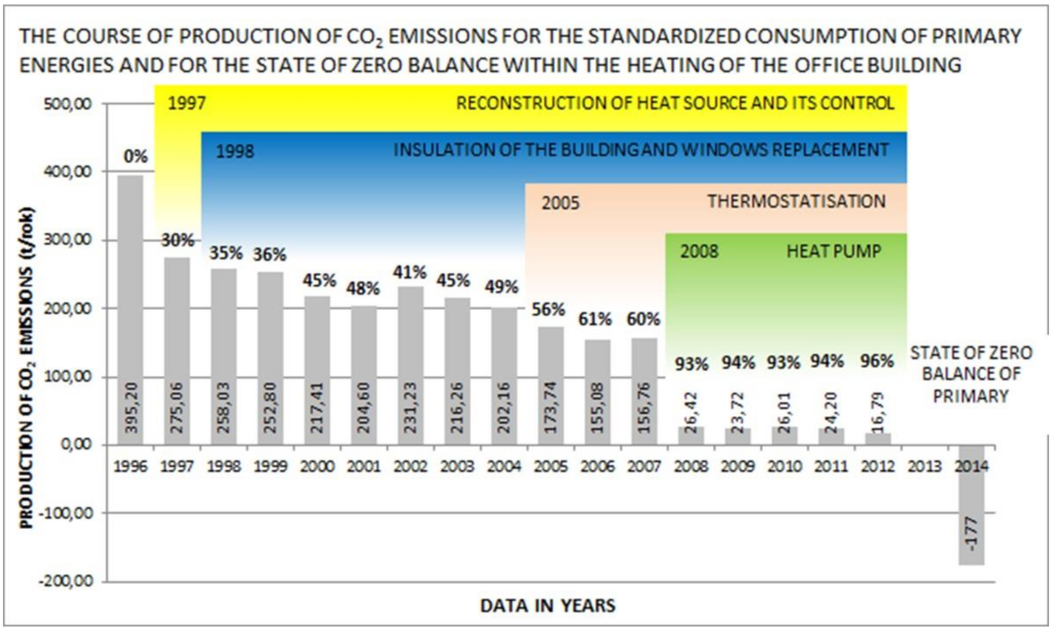
Chart no 5 shows the evaluation of the balance of all consumed primary energy sources with the achievement of the consumption of primary energy sources of 63.98kWh/m².a. A simple replacement of lighting devices by LED lights brings the building into the zone of the consumption of 60 kWh/m².a.



Picture 22 Standardized consumption of primary energy sources for providing the heat in office building

3.5.3 ECOLOGICAL LEVEL OF ACHIEVED STATE

Ecological level of solution is characterized by the achievement of 96% of savings of CO2 emissions. The realisation of a building with zero energy balance with a corresponding energy supply from the energy source can help to achieve the state when there is the gained saving of CO2 emissions higher by 177 t in comparison to 1966.



Picture no 23 The CO_2 emissions for standardized consumption of primary energy sources in the office building

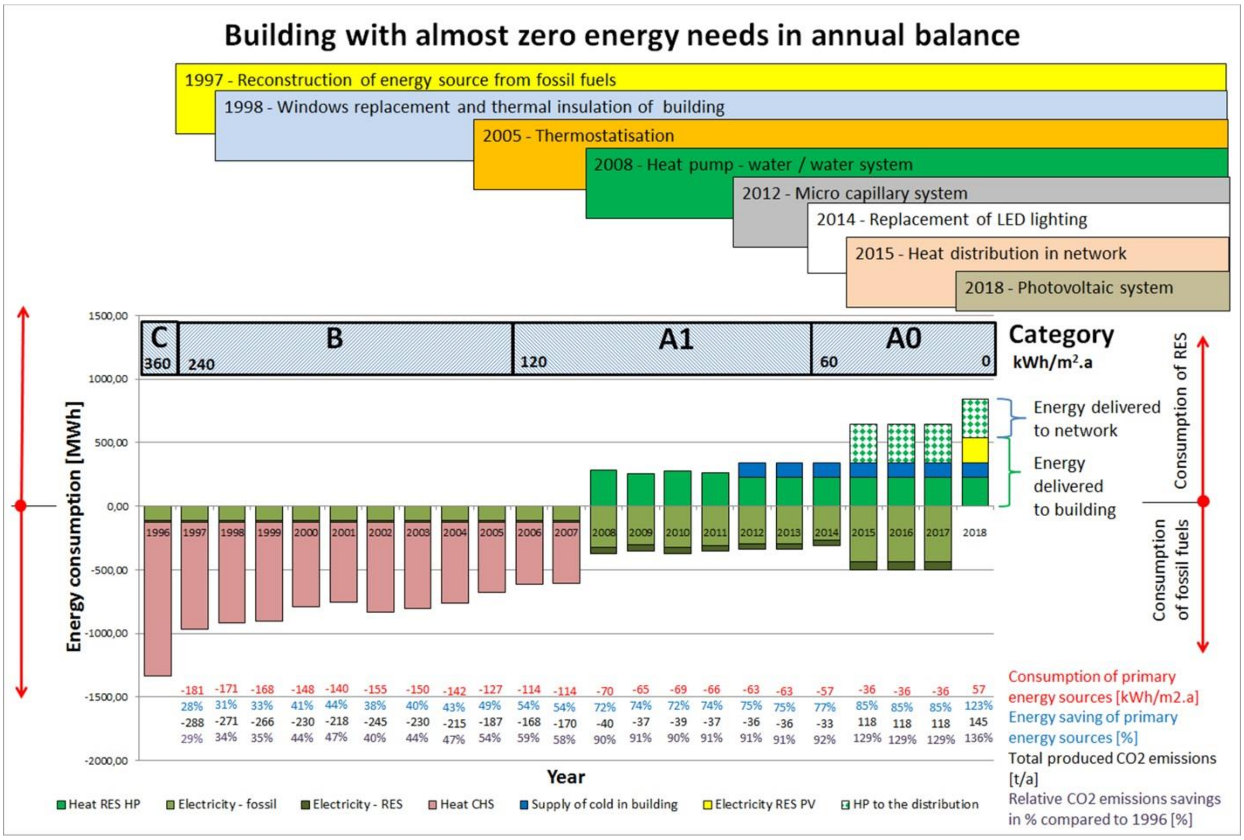
3.5. LEVEL OF INVESTMENT

The investment level is characterized by the solution with the investment return under the level of economic breaking point for each used technology. Except of the technologies of radiant ceiling system of heating the investment return within other used technologies is achieved from the energy savings. The investment return within the radiant system of heating and cooling is gained from the expansion of the range of function by an important change in the quality of internal environment what also influences the competitiveness of the building on the market and thus also the level of average occupancy. The energy transport is provided by a radiant component of energy in a decisive part what helps to expand the range of services in a building by the cold and thus solve the work efficiency rise, the reduction of morbidity and provision of resistance to heat waves that in the extreme increases the risk of organism collapse and death by up to 30% in the case of occurrence of heat waves It eventually means the increase in labour productivity of persons working in the office building.

3.6 COMPLEX ENERGY LEVEL OF TRANSFORMATION OF OFFICE BUILDING

Complex model of the transformation of the office building in 3 Murgašova Street, Košice includes the technologies determined for the improvement of the energy efficiency within supplying the building by the heat and cold and also the technologies increasing the

energy efficiency within supplying the building by the electricity. Only after achievement of corresponding parameters of the energy efficiency we can proceed to the transformation of the energy source of energy supplying achieved by the conversion of fossil energy source into the sources of renewable type. The advantage in Slovakia is the fact that the factor of CO2 emissions is in the energy mix of the electricity on the level of 0.23 t/ Mwah. Therefore, the replacement of the heat source where the heat is produced in DH more than 50% from coal by the renewable geo-thermal energy sources is suitable within the reduction of CO2 emissions.
The technology development in the last decade of the 20th century and the first decade of the 21st century enabled to solve the issue of energy efficiency at supplying the building by the heat and the cold in an economically efficient way. Similarly, the technology of a heat pump meets the criteria of long-term technology verified by the market and provides the solution with the investment return of the required quality measured by parameters of COP, SPF and parameters of reliability and lifetime. Synergistic effects achieved by the implementation of the ceiling radiant system of cooling and heating together with the improvement of the quality of internal environment are again focused on the reduction of the energy consumption with the assumption of the achievement of whole-year performance factor SPF ~ 7. The initial heat consumption in the reference year 1996 represented 8 times more than the electricity consumption. The solution of energy efficiency with the subsequent solution of the transformation of the supply by local renewable energy source of the heat and the cold represented the logical progress of primary orientation on the heat transformation and the expansion by the supply of the building by the cold. Gradual development of infrastructure for the electricity that also uses the technologies focused on the energy efficiency and the elimination of human factor create the conditions for the transformation of the building supply by the electricity in the form of the construction of a solar power plant.



Picture 24 A complex graph of the course of the transformation of the office building into a building with zero energy balance

The fact that applied technologies for the supply of the building by the heat and the cold represent the solution for climate changes was also very important at the level of buildings in two layers:

- Social layer - reduces the consumption of CO_2 emissions by more than 90%
- Local layer – it interrupts the heat waves by generated quality of internal environment in the summer.

It relates to the people that work inside the building. If the heat waves occur they represent the risk of an organism collapse in the range of 7 to 33%.

If a building is supplied by the electricity, there are gradually realized partial measures falling within the energy efficiency even before the realisation of a solar power plant. It is the installation of the sensors that detect the movement of people in the corridors and a corresponding light that switches on in the area around a person in movement. There is the project designed for the elimination of a human factor within the operation of electrical appliances by the means of individual measuring of the electricity consumption in every room separately. A significant reduction of the electricity consumption is represented by the installation of LED technologies planned in 2014. They are the following facts that postpone the decision about the realisation of solar energy to 2018-2020:

- There are no accumulation systems on the market that enable the accumulate energy on the level of buildings and ensure the quality of supply in 24 hour cycle
- Technologies of the smart grid and their implementation into operation is expected in 2020
- Investment return of solar power plants will be reached in 2014-2015 for the technologies with the efficiency of photovoltaic cells of 20% and more
- Doubling the efficiency of photovoltaic panels is expected around 2018 at the level of 40% to 45% together with the achievement of investment return
- There is an assumption that the suppliers of technologies will solve the problem of higher harmonized in a standard way
- Nowadays, there is happening the progress in the quality and efficiency of inverters and related technology
- An important role has got the fact that investments have to be distributed in time if they have to be realized from internal sources of the building
- The building will be able, after the construction of photovoltaic source, to cover its whole energy consumption for the operation within the energy balance and also supply the distribution network by the heat of 350 Mwah what also covers the consumption for building use (circa 120 Mwah per year) and reaches the state of zero energy balance.

3.7 CONCLUSION

The realisation of the premeditated plan of the building transformation within accepting the technical development and economical state of technologies enable to transform the building in a reasonable time horizon of 20 to 25 years with the investment return from the own sources of the building in full operation. A decisive factor of the transformation is the increase of the building value, namely:

- On the social and ecological level by the reduction of accompanying production of CO_2 emissions within the building supplying by energies
- On the level of the rise in quality of internal climate for providing lower morbidity and higher labour productivity and substantial reduction of the risk related to the

fatal collapse related to the exposition of a heat wave as the consequence of climate changes.

- On the economic level where the reduced operational costs linked to the supplying the buildings by energies create the building resistance against the risk of the rise of the price of the energies from fossil fuels after the shift to the down slope of global Hubbert curve.
- The rise in the quality of internal environment increases the competitiveness of building on the market

These facts harmonize the social interests with the interests of a user and the interests of the investor on the economic base of general advantageousness of the solution.

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