

Towards Sustainable Building in the Czech Republic

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CZECH REPUBLIC TOWARDS SUSTAINABLE BUILDING – CHALLENGE AND OPPORTUNITY

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Summary

The paper brings an overview in sustainable building development in the Czech Republic. Specific natural, climatic and economy conditions for the development of sustainable buildings are shown, and influence of extensive economic transformation after 1990 is discussed. The paper shows selected examples of implemented sustainable approaches in the design and construction of buildings in the Czech conditions in last years. Research and education plays in the process of implementation of sustainable building ideas key role. Many research projects being solved on national as well as international level are focused on different aspects of sustainability. A new study program directly focused to the problem of design of Sustainable buildings named Buildings and Environment started a year ago at the Czech Technical University in Prague, Faculty of Civil Engineering. All these above mentioned aspects create challenge and opportunity for the Czech building industry for the forthcoming period – towards sustainable building.

1. General context

Sustainable development is becoming a phenomenon of present which influences more or less all human activities. Buildings represent an essential element of the built environment created for preserving quality of human live. Construction and operation of buildings belong among the biggest consumers of primary materials and energy resources and environment pollutants as well. The population growth, depletion of primary materials, energy and drinking water resources, deterioration of environment (including the consequences of global warming in form of higher frequency of natural disasters) necessarily lead to more intensive search for new environmentally suitable approaches and solutions. It is evident that without considering economic aspects there is no way to achieve improvements in environmental and social areas of sustainable development. The sustainable building concepts offer many opportunities for significant advancement in the Czech Republic.

The Czech Republic is a part of Central European (CE) region. The countries in the CE region have many common from the point of view of nature conditions, historical connections and living and technology traditions, including construction techniques. However, in the second half of 20th century the development was different due to postwar division of Europe. Some CE countries like Austria, Switzerland and “West” Germany were developing politically in the democratic system with free market. In opposite, Czech Republic, Slovakia, Poland, Hungary, “East” Germany” and Slovenia were developing under control of Soviet Union in communistic pattern. The development of technology and construction techniques was at that time significantly influenced by these political conditions. The controlled communistic economy and centralized state ownership of the

most properties including large housings resulted in rather pure technical condition of a lot of existing buildings due to long term lack of regular maintenance and modernization.

After transition of political and economy system in the post communistic countries in 1990 the economy and technology was quickly developed. However, some differences still exist in the existing building stock constructed in the period of 40 years after the 2nd World War. Significant is large amount of mass-produced, prefabricated housings built after 2nd WW. For example in the Czech Republic approx. 1/3 of all population is living in prefab large panel buildings. Revitalization of concrete panel housing estates in sustainable way thus represents very important key issue.

At present all post-communistic countries in the region are already EU members and follow the same key priorities in the research as well as technical development in construction and maintenance of buildings. Development of new technologies, using of new progressive materials and advanced construction solutions lead to quality improvement of buildings not only in the economical sense, but also in environmental and socio-cultural. This all represents a huge potential for sustainable society development. The use of rating tools for sustainable building assessment is becoming to be more and more attractive not only from environmental point of view, but also from technical and marketing perspectives.

International conference Central Europe towards Sustainable Building - CESB07 [1] was held in Prague in September 24 – 26, 2007, as a part of the 2007 international conference series, organized by CIDEAS at Czech Technical University in Prague, iISBE, CIB, UNEP and other partners. The main goal of the conference was to provide a comprehensive overview of state of sustainable building in Central European region covering an area of Czech Republic, Austria, Hungary, Germany, Poland, Slovakia, Slovenia and Switzerland. More than 170 papers from 30 countries have been submitted. Approximately two thirds were from Central European region and one third from other countries of all continents.

2 Status of national development of performance targets for SB

Buildings in EU consume in average about 42% of all produced energy and are responsible for 36% of CO₂ emission and 40% of total waste. Average annual energy consumption in residential buildings is about 100 - 250 kWh/m². Some old houses in the Czech Republic reach even more 250 – 400 kWh/m². On the other hand the number of built low energy houses is step-by-step increasing and several passive houses have been also already built.

2.1 Natural specifics of Czech Republic

The Czech Republic consists of the Bohemian Highlands surrounded by several mountain systems. Climate in Czech Republic is mixed, influenced by east continental and west oceanic climate. Predominant are west winds bringing relatively wet weather. Continental influences are marked by large fluctuations in both temperature and precipitation. In general, temperatures decrease with increasing altitude but they are relatively uniform across the country at lower elevations. The periods with very low winter temperature (in January and February by -20 °C in short extreme situation) and without significant sun radiation in these months must be considered. On the other hand, possible longer periods with very high continental summer temperatures (above 30 °C) must be taken into account, too. Such fluctuation in temperature and solar radiation require designing buildings to be well insulated for cold winter as well as to be ready to prevent overheating.

2.2 Changes in general attitude to sustainable principles

The understanding and accepting of sustainable principles, especially concerning built environment, is becoming to be more and more frequent by population, especially by younger people, at least in a declarative way. However, the acceptance of sustainability issues by decision makers and other stakeholders is still not sufficient. There are still only few developers considering the sustainability issues as a market drive mechanism. Some companies from building industry started to work with sustainable approach and first few results are already visible.

Concerning buildings, the low energy concepts including use of solar systems are more frequently asked at family houses.

The Czech Republic followed the international process Green Building Challenge and iiSBE organization and established in 2005 the Czech Sustainable Building Society (CSBS) iiSBE Czech. The CSBS is an official representative of iiSBE in the Czech Republic and keep the key role in promotion of SBC principles into the Czech construction sector. CSBS iiSBE Czech together with the research centre CIDEAS (at the Czech Technical University in Prague) started the process of the development and introduction of a building complex evaluation system, supports educational activities and the web information system SUBSTANCE related to sustainable built environment development (www.substance.cz).

More over there are several other groups and non-profit organizations dealing with particular problems of built sustainability, like Center for Passive Houses, Society for Environmental Engineering (STP), information web-portals focused on energy saving measures and technical services design and technologies, etc.

3 Status of adoption of policies

The principle orientation of the Czech policy in the agenda of sustainability and environment is based on the EU priorities in this field and is published in several official documents. In 2006 has been published strategic document State Environmental Policy of the Czech Republic 2004 – 2010 (available in English at www.env.cz).

3.1 Czech Republic, Kyoto targets and further challenges

Kyoto target for the Czech Republic is – 8 % compared to 1990 reference year. In this year aggregate emissions of all considered GHGs equaled in the Czech Republic to approx 190 Mt of CO_{2eq}. Extensive economic transformation (mainly from heavy industry to light and service industries) after 1990 resulted in the decrease of GHG emissions by approximately 24 %. Future projections show further possible decrease of GHGs, depending on scenario considered (Tab. 1).

	1990	1995	2000	2005	2010	2015	2020
Reference scenario (Mt of CO ₂ eq.)	187.5	142.7	141.8	126.4	128.3	123.8	121.2
High growth scenario (Mt of CO ₂ eq.)	187.5	142.7	141.8	141.5	141.7	146.6	145.9

Table 1 GHG emission projections for reference and high scenarios. Projections have been constructed on the basis of the original value of the total emission balance for 1990. Source: Ministry of the Environment of the Czech Republic, OECD Economic Survey 2004, www.oecd.org

Although the total amount of CO₂ emissions is in the Czech Republic significantly lower than in the year 1990 the amount of released CO₂ per capita is in the Czech Republic much higher than in the most of other European countries – see Figure 1. This creates necessity (more moral than legal) to make additional actions towards reduction of GHG emissions in the Czech Republic within the near future – in spite of the Kyoto targets has been already fulfilled. There is no more space to fulfill “automatically” (like during economy transformation after 1990) more strict requirements, which are under discussion now at EU-level.

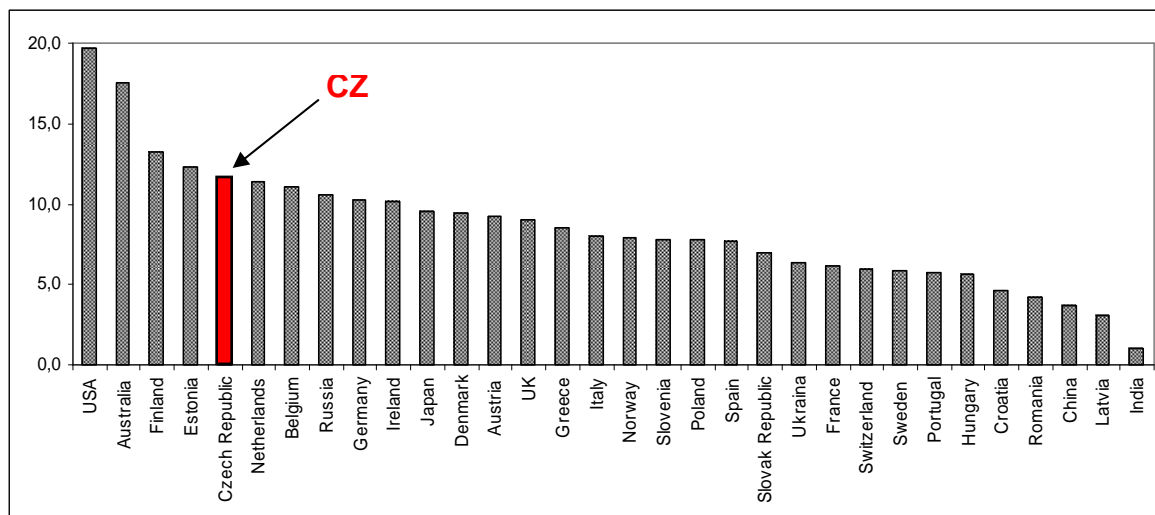


Figure 1 Carbon dioxide production per capita in selected countries. Source: IEA Key indicators 2004

3.2 Public support

The systematical and long-time functioning system of public support for activities in the field of built sustainability is not available. There are several incentives, particular governmental supporting programs (mainly short-time oriented), but the general perspective is still missing.

The green electricity production, is supported by Energy act and corresponding governmental ordinance. The guaranteed prices for 15 years for PV-electricity (since 2008 for 20 years) changed the situation within the short period of time significantly. The installed PV- power in the Czech Republic is increasing (in 2004: 0,36 MWp, 2006: 0,87 MWp, 2007: 5,35 MWp). The feed-in tariff is 13,46 CZK/kWh (corresponds 0,54 EUR/kWh by rate 1 EUR = 25 CZK). The green bonus is (public supported own use of green electricity) 11,65 CZK/kWh (corresponds 0,50 EUR/kWh).

Similar clear approach and resulting successful tendency would be highly needed in the categories of “simple” energy refurbishment of buildings.

Solar thermal systems, biomass heating etc. can be partially supported by state programs organized by State Fund for Environment. However, the conditions are changing from year to year.

In the period 2007-2013 the Czech Republic has a unique opportunity to use EU – structural funds for substantial changes in infrastructure, including refurbishment of existing building stock, for systematic support of emerging technologies like passive buildings, solar and other renewable energy technologies etc.

Private housing projects for energy improvements should be co-financed from an extra created fund since 2009, using financial effects from Green Investment Scheme (GIS) by CO₂ emission trading.

4 Status of adoption of SB by the investor community

The process of adoption of SB by the investor community is in the Czech Republic relatively slow. The main reason is currently existing relatively big demand on new housings – especially in big cities like Prague and Brno. Most of the new developed residential areas around big cities are very often practically sold out before construction works start. Thus developers are not forced by market to increase total performance quality of buildings temporary. However, in specific aspects like operation energy consumption could be recognized in last few years a significant progress. The number of new low energy houses is continuously increasing due to current investors demands, mainly built by small companies. Large stakeholders in the Czech building industry (like Skanska CZ, Bovis Lend Lease, Colliers CZ) are more active now in trying to implement the sustainable building approach in their business. Such companies could together with CSBS play key role in the preparation of the Czech Green Building Council. This process is already under discussion between WGBC, CSBS and other partners from the Czech building industry.

5 Status of education and training in SB

Recently, some changes are visible in university education in the Czech Republic. The sustainability agenda is being introduced step-by-step in curricula of different study programs for future civil engineers and architects. New master study program Buildings and Environment has been recently introduced at Faculty of Civil Engineering at CTU in Prague. This study program is focused on principles of integrated design, life-cycle approach, sustainability assessments, buildings physics, material related issues, technical services etc. The program is taught in Czech and English. The number of students is increasing. In the first year 2007/08 there was 47 students. In the next year 2008/09 there will be already around 80 students. In the following years is expected even higher number of students.

Since 2006 courses on sustainable building are organized at CTU also for practicing architects and building engineers (www.substance.cz/kurzy). They are available in two forms – one week intensive course (5 full days of lectures and practical trainings) and electronic course available on internet. The preparation of these courses was financially supported by EU funds.

New forms of SB education are being developed and tested. In spring 2008 has started iiSBE videolecturing project (Carbon Neutral Lecturing) when R. Rovers from Wageningen University in Netherlands and P. Hajek from CTU in Prague successfully ran a pilot for teaching in each other master courses via a Skype video connection. On April 10 P. Hajek was lecturing in Prague for students in Wageningen, on May 23 R. Rovers was lecturing in Wageningen for students in Prague. This form of “guest” lecturing enables immediate exchange of information about SB developments and approaches in different countries, without need for travelling. It is expected to continue with this form of lecturing. Also other universities expressed willingness to join this network.

6 Status of adoption of new SB technologies and techniques

6.1 Life Cycle Approach and Integrated Design

Integrated environmental design represents a new approach integrating material, energy, structural and environmental aspects in one complex design and optimization process. This process should result in the development of energy and material efficient buildings throughout entire life cycle. This should cover not only (1) energy for operation (heating, cooling, hot water supply, ventilation, lighting, use of electric appliances etc.) but also (2) energy associated with the use of construction materials (embodied energy), (3) energy and material used in technology processes (construction, refurbishment) and (4) energy during demolition.

It is essential that at present the energy needed in operation phase for heating and cooling represent for the most of current buildings the major part of energy used. On the other hand the most of material is used in construction and reconstruction phases.

6.2 Energy efficient buildings

There is a potential for design and construction of 10 times and more energy effective and fully functional buildings in term of space heating in comparison to existing building stock. It is necessary to apply new techniques towards energy-optimized building. Energy optimization can be performed - up to zero-energy or energy-plus buildings (the building in which energy production of the building itself is larger than its annual total need).

Use of renewable energy systems in buildings has a large potential for further development. The technologies for particular systems are available, further improvements are possible and especially by photovoltaic (PV) highly expected. A systematic methodology and designer oriented tools are missing. Such innovative buildings must be designed and built consequently, taking into account the best available technologies and components, knowledge in building physics, theories of technical systems (HVAC). New generation of information technique can be used for better building operation (intelligent buildings). In general, a very effective source (and very frequent used source, mainly in electronic way) of examples of good practice are the information available by the "neighbors" - in Germany and Austria – with their fascinating development of passive houses, solar technologies, etc. The possibilities to compare different approaches in the countries with similar climatic condition and similar traditions are very valuable and can speed-up the implementation of new technologies.

General perception of low-energy strategies finally seems to be visibly changing in the Czech Republic. This is not just an evident result of growing energy prices and other negative expectations, but also stems from the dissemination of information on successful realizations. This positive trend needs to be further supported at the levels of applied research, pilot projects, promotion and other informational activities and education. The limits to applying progressive technologies and approaches more quickly create intellectual stereotypes that are too often more difficult to overcome than the technical barriers. Fig.2 illustrates a new housing development in Koberovy [2] – 13 energy passive houses with unified timber structure, only slightly differing in size and design of building envelope. Fig.3 presents the SEV Slunakov building. This education and ecological centre is in operation since January 2007 and the building itself could be used as a part of environmental oriented education. Fig.4 illustrates one of the larger PV-installations.

Czech technical standard on Thermal Protection of Buildings, Part 2: Requirements (CSN 73 0540-2 (2002, 2007)) was written partially in a new way, with certain professional overlap to enable the wider understanding of con-text of thermal protection of buildings, indoor comfort, HVAC-system and built sustainability. Even paragraphs and criteria from its informative only Annex A Design instruction are used by contractual parties, as a guideline for low-energy buildings. New specific technical standard dealing with unified declaration scheme of energy passive residential buildings (in the first run for family houses) is under final preparation.

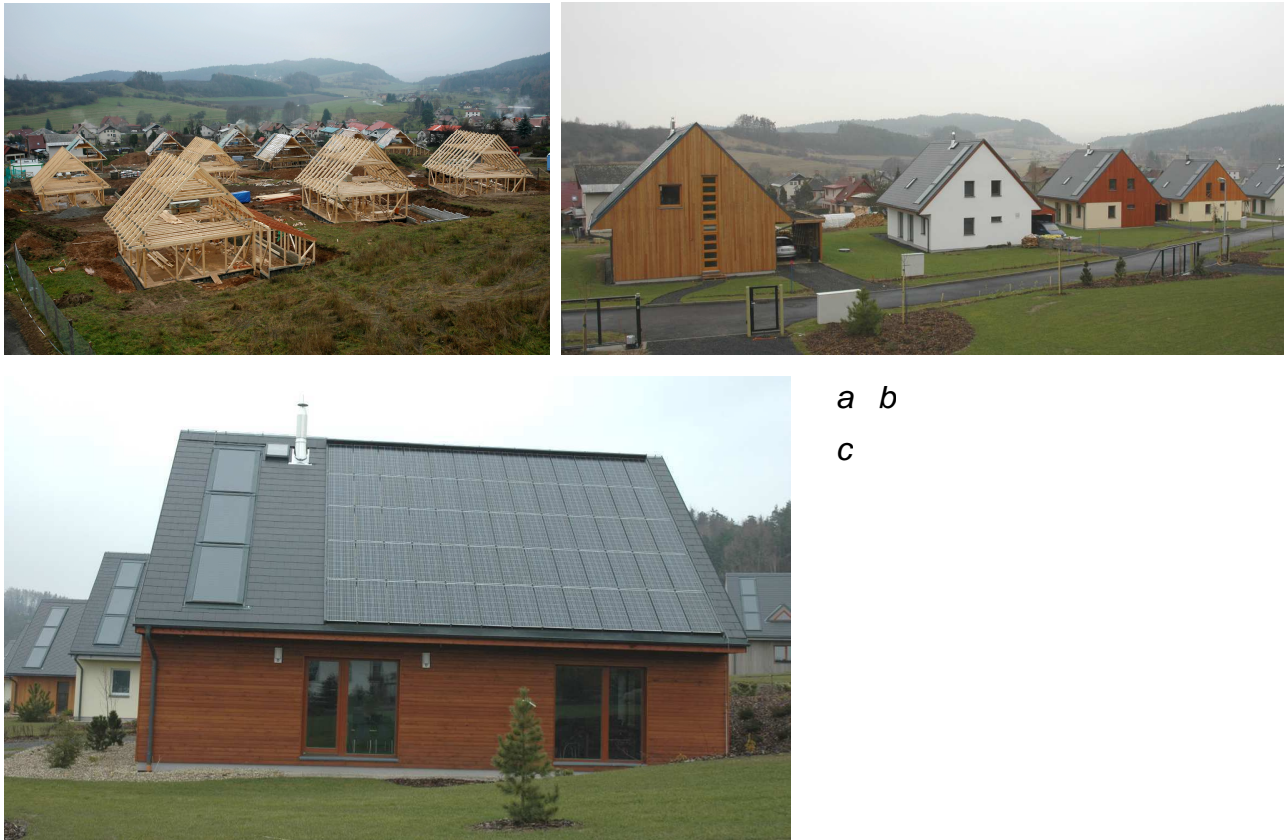


Fig. 2 Passive houses in Koberovy (Petr Moravek, Jan Tywoniak et al.)

a) loadbearing structure

b) finished residential area

c) zero-energy house for information and education having large PV-roof



a b
c

Fig. 3 Building of Education and ecological centre Slunakov. Low-energy building with passive house components covering the energy need from renewable sources (Projektil architekti)
 a) total view
 b) fully integrated in the nature
 c) training in front of building



Fig. 4 Part of PV installation at CTU campus building in Prague (2005). Several universities and high schools in the Czech Republic are equipped with PV systems for research and education. Financing up to 90 % from governmental sources (program Sun to schools)

6.3 Material efficient buildings

Non-renewable natural sources are irreplaceably exhaustible and regeneration ability of some renewable resources is limited. Thus, there is an undisputed need for reduction of consumption of primary non-renewable materials. The extraction of natural raw materials and manufacturing of products are associated with corresponding environmental impacts, including embodied GHG emissions.

The amount of embodied energy in construction materials is becoming more and more important criterion of sustainability of buildings and reduction of embodied energy and embodied CO₂ through optimization of material use is essential. The increasing use of renewable natural materials, recycled materials as well as high performance materials (like high performance concrete, new composites etc.) can thus increase the overall sustainability of the new building design concept.

Collection, sorting and recycling of municipal waste has been largely developed in the Czech Republic during last years. Since January 2002 new Law on Waste 185/2001 Sb is in force and all towns, villages and other settlements are responsible for collection, sorting and reuse of all waste.

Building construction typically uses large amounts of materials in relatively less demanding techniques. Therefore, there is a high potential for the use of secondary materials obtained from recycling of waste generated by other industry and from municipal waste. The main concern should be paid to those waste materials which are produced in large amounts and just a small amount is recycled – like non-sorted waste plastic (from municipal waste yellow collecting containers) and laminated carton drink boxes. Fig. 5 shows use of lightening installation fillers in the construction of Senior Centre in Moravany. More information about the use of recycled waste in building construction is available in [3], [4] and [5].

Use of renewable materials has been also increased in the last 15 years. Especially use of timber framed structures for family houses is becoming to be more popular. However, still the percentage of timber structures is in the Czech Republic much lower then in many European countries, although the potential is due to level of domestic wood

production much higher. Fig. 2a and Fig. 3a show good examples of timber structures designed with the intention to be sustainable in the complex manner. In the building SEV Sluňakov on Fig. 3 are also used walls from unburned clay bricks.

There is also a big potential for the use of high performance silicate materials (UHPC, HPFRC) to form ultra thin shell structures with higher reduction of the use of primary raw materials, and correspondent reduction of associated environmental impacts.



Fig. 5 Senior Centre in Moravany – composite RC floor slab with installation fillers from recycled municipal waste plastic, August 2000

7 Status of adoption of SB whole-building performance rating systems

The methodology for evaluation of energy performance is already standardized within EU. More precise level of estimation of all energy flows in building system should be developed, separately for different energy carriers, results in term of primary energy and equiv. carbon dioxide,...etc.

Several methods and tools have been already developed and are used for complex assessment of buildings from a range of issues of environmental aspects and/or sustainability (GBTool/SBTool, BREEAM, HQE, LEED, GreenGlobe etc.). Current trend in Europe is to develop EU standard and methodology for labeling of total quality of buildings. Research group from CIDEAS was also involved in FP6 EU project LEnSE (Methodology Development towards a Label for Environmental, Social and Economic Buildings – EU FP6 research program). The goal of this project was to propose the form of label showing the performance quality from environmental, social and economy issues point of view.

In the Czech Republic does not exist yet widely recognized and used specific Czech evaluation tool. Translation of GBTool 2005 into Czech language was finished in 2005, however, this tool has been used just for research and testing purposes. Based on particular results of this project and based on participation on the Green/Sustainable Building process controlled by iiSBE, the Czech SBTool has been developed and is being tested.

The SBToolCZ is a building performance assessment tool designed for assessment of buildings in various phases of their life cycles. For SBToolCZ has been developed adapted structure of indicators, benchmarks and weights based on the original SBTool structure and using some experiences from development of LEnSE methodology. The parameters included in the system cover sustainable building issues within the three major areas: environment, social and economic issues. The system is designed on three levels including the core of the application, an expert level and the user's boundary-line. Building properties, assessment boundary conditions and criteria are sorted in a database form.

In 2007 the biggest new office building in the Czech Republic – CSOB Bank in Prague (Fig. 6) has been evaluated by US team Buro Happold using LEED rating system. This is the first Czech building obtained LEED certification – gold. This building has been designed to be environmental friendly, with high emphasis on energy efficiency and high quality of internal environment for users. Flat roofs are covered by green roofs with trees and facades are prepared for creepers.



Fig. 6 CSOB building, Prague, Radlice. Design: AP Atelier, Arch. Josef Pleskot, Contractor: SKANSKA CZ a.s., completed: December 2006

8 Research in SB

Research priorities of Czech grant agencies are mostly consistent with EU priorities. Thus many research projects are oriented to sustainable issues, including efficient use of materials, energy, development of high quality of internal environment and others. The emphasis is on the implementation of research results directly into the practice.

In 2005 the research centre CIDEAS has been established (Centre for Integrated DEsign of Advanced Structures). The centre is a research unit for basic and applied research of new progressive structures which will meet a wide range of demands and comply with sustainable development principles. The initial concept was driven by the effort to facilitate cooperation of young research teams managed by top researchers at three largest civil engineering faculties in the Czech Republic, as well as specialists and staff involved in cooperate research in major Czech construction companies (SKANSKA CZ, Metrostav and SSZ). Research and development of techniques and tools for design and construction of sustainable buildings represent essential part of the research of the

CIDEAS centre. Some topics recently are being solved: Life cycle assessment and development of assessment tools, Low-energy and passive houses, Alternative materials, Possibilities of utilization of new earthen structures, Use of recycled materials, Earth-to-air heat exchangers and others.

9 Conclusions

The high potential for improvement of technical, energy and environmental parameters of new designed and existing building stock in the Czech Republic is evident. However, up to present, in the Czech Republic was built only a small amount of buildings in the standard going near to the "sustainable" level. The step by step improvement of the average standard of the Czech building stock (from the sustainability point of view) is possible, but it is conditioned by (a) development of technical basis (know-how, database, product base, technology of production and construction etc), (b) development of legal support for implementation of sustainable principles in building practice and by (c) implementation of economy stimulation.

Energy related problems, already recognized by public can be effectively used as an introduction for increasing sensibility in broader agenda of sustainability of built environment. At the same time, wider perspectives and strong visions are needed to try to solve serious problems at urban scale. The problems of sub-urbanisation (urban sprawl) in areas around larger cities are substantial and should be solved in parallel with particular problems of buildings.

The role of building industry is essential on the way towards wider implementation of sustainable agenda into construction of buildings. Building industry should play in this process the leading role. From this perspective the participation of representatives of the Czech building industry together with researchers from Czech universities in the ECTP (European Construction Technology Platform) is very important.

Challenge and opportunity are clear and evident. It's the time for sustainable building.

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References

- [1] Proceedings of CESB07 Prague – International Conference Central Europe towards Sustainable Building (Prague 24.-26.9.2007), CSBS iisBE Czech
- [2] TYWONIAK, J., MORÁVEK, P.: Optimized design concept for 13 passive houses in Koberovy, Czech Republic. In: Proc.10.International Passivhaustagung 2006, Hannover 2006
- [3] HÁJEK, P. The Way towards Sustainable Construction by the Use of Recycled Municipal Waste. Proc. of RSC06 – Rethinking Sustainable Construction, Sarasota, 2006
- [4] FIALA, C., HÁJEK, P.: Environmentally Based Optimization of RC Slab Floor Structures. Proc. CESB07, Prague, 2007
- [5] MUKAŘOVSKÝ, J., HÁJEK, P.: Savings of Natural Resources by the Use of Elements from Recycled Municipal Waste in Building Construction. Proc. CESB07, Prague, 2007