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Obsah

1. Municipalities Are Unprepared To Face The Incoming Changes In The Energy Sector

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Abstract

There is a significant gap between the incoming changes in the energy sector relevant for municipalities on one hand and the ability of municipalities to tackle them on the other hand. In the field of energy supply, distribution and savings these threats occur or become soon actual: increasing unit prices of both electric energy and natural gas; the energy spot pricing since 2023; the requirements contained in the Act No. 3/2020 Col. of Energy management; the common press to reduce CO_2 emissions; the reduction of energy import from Russia, the energy communities driven by citizens; redesign of the electric tariffs structure in the Czech Republic; the new version of Energy Performance of Buildings Directive approved by the Parliament EU. These changes influence each energy consumer and mainly the municipalities because of their high energy consumption. The possibilities of the municipalities to tackle the consequences of changes mentioned above is investigated in this article. The main person responsible for the municipal reaction will be the municipal energy manager. Many municipalities do not employ such person and in many others the energy managers have not technical education. The survey conducted among Czech municipalities with revealed that 27,4 % municipalities do not employ any energy manager. Some of them are just in process of hiring this work position. The most energy managers 16,7 % are economists and just 11,3 % are civil or electrical engineers. The 17,7 % of them are the mix of various university specializations far away from energy issue: law, security, forest engineering, management of sport, mechanical engineering, pedagogy. The disproportion between unprepared municipalities and coming changes should be minimalized by the appropriated education. The courses for responsible employees in magistrates should be prepared. Technical universities should offer the study program for municipal energy management. This job needs mix of knowledge from electrical, civil and mechanical engineering.

Keywords

Energy management; Energy management Act; ISO 50 001; Performance of Buildings Directive

Introduction

The energy sector has changed dramatically since 2021 and the other changes are expected in near future. The changes influence all the energy consumer. The municipalities are especially vulnerable because they operate the buildings and equipment where the consumption cannot decrease under the given limit: e. g. the temperature in elementary or mother schools is determined by the government regulatory No. 306/2022 Coll. The municipals' possibilities to control the impact of mentioned changes will be investigated in this article. The only way how to face these challenges is to establish municipal energy management system (EnMS). The head of EnMS is energy manager.

The energy manager job description

The purpose of EnMS is to reduce the both energy consumption and expenditures for it. The main responsible person is the energy manager who should establish the energy management system and solve the problem using the holistic approach. The main duties of energy manager were as following: establish and operate EnMS including the database of all types of delivery points; formulate the ideas of measures for energy consumption reduction; monitor energy consumption of municipal buildings and public lighting; purchase the energy using stock exchange; meet the legislative requirements; prepare the investment projects; fulfill other duties related to energy [1].

The significant motivation for each job is the salary. The energy manager salary belongs usually to the 10th or 11th salary class with possible personal bonus. According to Government Order No. 341/2017 Coll. the salary in the 11th class starts at 22 980 CZK for employee without any praxis up to 33 790 CZK for the employee with 32 years of praxis. The necessary requisite for 11th class is university degree [2].

The recent changes in energy sector

- increasing unit prices of both electric energy and natural gas

The unit prices of electric energy and natural gas have grown slowly since 2021 and increased rapidly in September 2022 – see the Figure 1 below. The municipal expenditures for energy inevitably follow this trend because the measures to reduce energy consumption cannot be done as quickly as the price rose. Moreover, the reduction of energy consumption as the result of finished measures does not reduce the expenditure if the energy unit price grown more than the consumption was reduced.

Figure 1 The history of unit price of electric energy between 2014 and 2023 (source: [3])

- the energy spot pricing since 2023

The unit price of energy used to be constant for the whole period of the energy contract. This praxis has changed since 2023 when the suppliers started to derivate the unit price from the spot prices. The spot prices are given by the immediate balance between the demand and supply of the energy on the market. This balance is watched by the government institution Operátor trhu, a. s. (OTE) and this institution states the unit price in Euro for each hour of next day. The spot prices are very volatile and unpredictable – see the Figure 2 below. The spot price can be even negative in case the electric supply is higher than demand. The correct pricing must involve the consumption in each hour, the price given by OTE and the exchange rate valid for given day. The equation for the price is:

$$PC = \frac{\sum_{h=1}^{N} PC_{EE_h} * Sp_h}{\sum_{h=1}^{N} Sp_h} \quad (1)$$

$$PC_{EE\_h} = DT_{EE\_h} + G \quad (2)$$

PC – the total payment for consumed energy without VAT and tax of electric energy; Vi – the basic period for energy price (nowadays 1 hour but can be restricted to 15 minutes); N – number of basics period in the invoiced period; Sp_h - the amount of consumed energy during the basic period; DT_{EE_h} - the price of energy for hour of the day given by the OTE in €/MWh; G – the supplement charge added by the energy supplier. The ordinary customers without technical education cannot understand the equations (1) and (2) alone to check the enumerated amount to pay. Because of unpredictable unit prices of energy, it is hard to plane the expenditures for energy. The prediction of expenditures is essential for municipal budgeting. The pricing of natural gas is analogic however the unit price remains constant for whole day and the spot prices are published for the whole week.

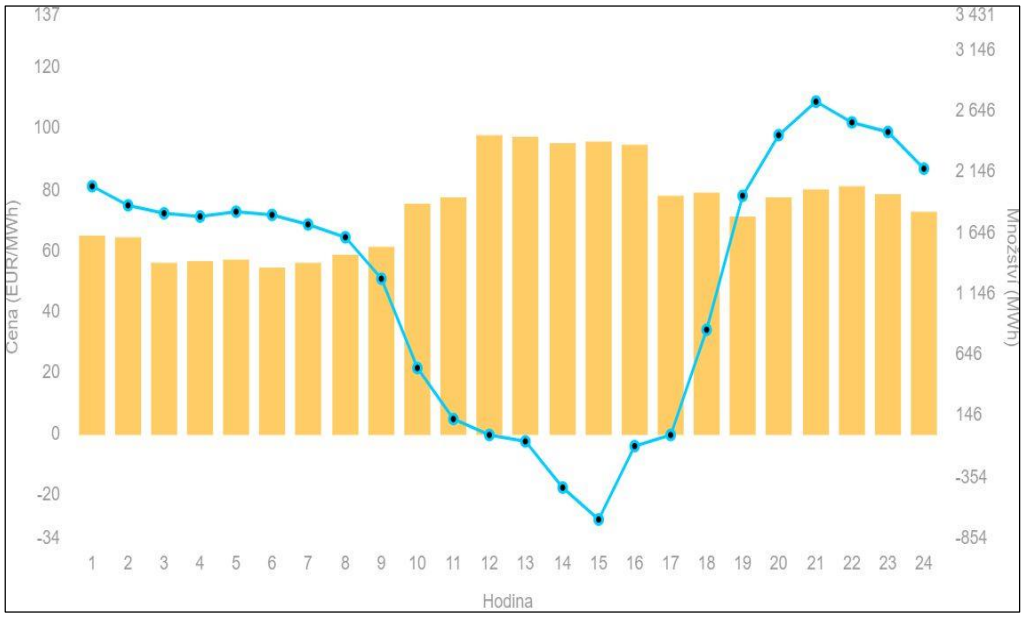

Figure 2 The hourly price of electric energy e.g. on Sunday 4th June 2023. The price was negative between 3 PM and 5 PM (source: [4])

- The requirements of the Energy Management Act No. 3/2020 Coll.

The Energy Management Act No. 3/2020 Coll. requires the municipality to conduct the energy audit covering all the energy equipment owned by the municipality. An alternative is to implement the energy management system according to international standard ISO 50 001. Both possibilities anticipate a data about energy consumption and about the properties of energy equipment installed within the city. These data should collect and archived the municipal energy manager. In case the energy manager is not employed neither the energy audit nor the ISO 50 001 can be managed and the municipality risks the penalty up to 500 000 CZK [5].

- Common press to reduce CO_2 emissions

The CO_2 emissions become an issue for the whole society. The various organizations (including energy companies, universities, car producers, transport companies) declare their commitment to reduce CO_2 emissions. The leaders of the municipalities want to follow this trend and try to find opportunities how to reduce emissions within their towns. The energy manager should find the appropriate realization of such commitment regarding the costs and benefits of this measure.

- Energy import from Russia reduction

Since the beginning of the war in Ukraine in February 2022 the EU member states intend to reduce the import of natural gas and oil from Russia. This led to the generous subsidy concerned to energy performance of building enhancement and replacement of heat sources based on coil and natural gas. The municipal energy manager should use this opportunity to prepare the subsidy applications focused on municipal buildings energy performance.

The incoming challenges in energy sector

The municipalities will face to several challenges of the energy sector in near future. The most important are these:

- Energy communities driven by citizens

The current boom of photovoltaics power plants (PV) and increasing unit price of electric energy result to the demand of sharing electric energy between group of several participants (consumers). Group of consumers with different schedule of demand for electricity (physical persons, municipality, small commercial companies) can invest together to the common energy source (typically PV) and consequently share the produced energy. This approach called energy community will be legalized by the novelized Energy Act, which become valid in the 2024 [6]. The PV is commonly placed on the roof of large building. The large municipal buildings (elementary and mother schools, administrative, buildings for culture) are especially appropriate for this purpose because their internal consumption is relatively low and is strictly scheduled. It is perceived as very attractive by many citizens and they want to establish the energy community together with the municipality. The energy manager should create the rules for energy community respecting the expectations and needs of all participants.

- Electric tariffs' structure redesign

The current structure of electric tariffs should be redesigned. The low-level tariffs (C25d, C35d, C45d, C56d, C57d), which allow the lower payments for distribution from 8 up to 22 hours, disappear. The customers will be charged according to their circuit breakers value and the actual power drown from the electric grid. The higher power implicates the higher payments [7]. This redesign requires adequate disposals in the municipal delivery points of electric energy. These disposals should be formulated by the energy manager.

- Prepared Energy Performance of Buildings Directive

The new version of Energy Performance of Buildings Directive (EPBD IV) was proved by the European Parliament in 2023. The main goals of the Directive are these: highly energy efficient and decarbonised building stock by 2050; a stable environment for investment decisions; enable consumers and businesses to make more informed choices to save energy and money [8]. The most important consequence for municipal energy management is that the new public buildings should produce zero emissions since 2026. It means to purchase the energy generated from renewable sources only. This requirement will be applied to both private and public new buildings since 2028. The heat sources based on solid fuels in buildings will be forbidden since 2035. All new public buildings should be prepared for solar energy utilization [9].

All above mentioned challenges which are now in process or become valid in near future notably redefine the current approach to municipal energy management. It is obvious that main responsibility to tackle these challenges will hold the municipal energy manager.

Methodology

Two main information sources were combined and compared. The primary information about energy managers currently employed within Czech municipalities was obtained by the survey organized by the author. The survey was conducted among Czech municipalities with the inhabitant number from 10 000 to 100 000 during the April 2023. The questionnaire was based on Google Forms because of user friendly interface for both respondent and researcher. The link to the questionnaire was send by email to the secretaries of magistrates in the mentioned municipalities with the instruction to forward it to the employee responsible for the energy management. The number of addressed towns was 124 and 50 % of them replied. The return rate is higher than it used to be in similar surveys. The questions focused on two main topics of energy management – the organizational basis and the personnel cover. The energy manager existence, his/her education and work load were investigated.

The second source of information were the official texts from Energy Regulatory office (ERÚ); the Act No. 3/2020 of Energy management; the prepared EU Direction EPBD IV; the graphs from energy stock exchange; the contract with energy supplier and other.

Results

The energy managers in nowadays Czech municipalities

The survey revealed that the energy manager position is placed in 66,1 % of responding towns. This position does not exist in 24,2 % of respondents, the work position was being prepared during the survey in 3,2 % and 6,5 % was different reply – see the Table 1 below. The workload of energy manager varied from 0,1 to full FTE. Survey revealed that in most towns the EnMS is operated by the employees whose job duties contain many types of tasks and EnMS is one of them. The rest duties were not relevant to EnMS.

Table 1: Was established the energy manager work position? (source: author)

Does exist the work position of energy manger in the town?	number	[%]
yes	41	66,1
no (without any comment)	15	24,2
just in process	2	3,2
other replies	4	6,5
total	62	100

The survey showed various types of the education in the group of the energy managers. The university degree (both MSc. or Bc.) had 52,2 % of them – see the

Table 2 below. The most frequent specialization were economists with the share 16,1 %. The electrical engineers were 9, 7 % and the civil engineer was observed just one time (1,6 %). The rest (17,7 %) was the mix of various university specializations far away from energy issue: law, security, forest engineering, management of sport, mechanical engineering, pedagogy.

Table 2 The education of energy managers (source: author)

energy manager education	specialization	number	[%]
university (MSc.)	electrical engineering	6	9,7
	civil engineering	1	1,6
	economic engineering	10	16,1
	other	11	17,7
university (Bc.)	specialization not investigated	4	6,5
high school	specialization not investigated	11	17,7
town without energy manager		19	27,4
total		62	100

Conclusion and discussion

It is obvious that responsible reaction of each municipality to the challenges mentioned above requires well prepared energy manager with both appropriate education and experience. The most changes concern on energy supply, energy delivery and buildings measures. It implicates the civil engineers and electrical engineers will be needed. Moreover, adequate experience cannot be obtained without suitable background which is the technical education in civil or electrical engineering. According to the replies in the survey several towns opened the work position of energy manager.

In case the municipality is not prepared to the changes or does not reflect them, the expenditures for energy will increase and this trend pushes the municipal leaders to face the problem. The solution can be to gain the energy manager as the internal employee of the magistrate, nevertheless this work position is worthy in the towns with more than 10 000 inhabitants. There are approximately 6600 small villages and towns with relatively low number of municipal buildings to employ energy manager. In such case it makes sense to hire an external energy manager in common for several villages.

The real obstacle is the actual shortage of experienced energy manager. This work position combines the knowledge from electrical, civil and mechanical engineering beside the economic as well. The universities should offer the study program for energy management. This needs the cooperation between relevant faculties. The students of architecture should be led to design the buildings meeting the requirements of the EU Directive EPBD IV. The energy performance of the building can be easily affected during the phase of design. Any additional measure applicated to existing building is expensive and with limited benefits. The knowledge of energy managers in praxis should be reinforced by courses organized by professional association or other relevant institution (Ministry of trade, university). If the municipalities will be prepared, the mentioned challenges can bring the fruitful results.

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2. Urban Public Space in The Context of Urban Densification

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Abstract

Urban public space and open spaces are one of the key elements of the urban densification debate. The need to increase housing affordability in the context of the housing crisis, leads to a drive to use existing land to achieve higher densities and improve the efficiency of urban space use. However, in the context of urban densification, much of the public is worried about the reduction of undeveloped space and the resulting lack of public green space.

Keywords

Public space; city; urban planning; housing

Introduction

Urban public space and open spaces are one of the key elements of the urban densification debate. The need to increase housing affordability in the context of the housing crisis, leads to a drive to use existing land to achieve higher densities and improve the efficiency of urban space use. However, in the context of urban densification, much of the public is worried about the reduction of undeveloped space and the resulting lack of public green space.

Today's cities face many challenges to which they must respond. Urban planning, with a focus on anticipating potential risks, with an emphasis on issues of housing affordability, excessive traffic congestion, inadequate amenities and lack of environmental resilience, is a very important component of the preparation phase of new developments and their surroundings. Urban planning that encourages higher densities in conjunction with other conditions such as mixed functional use, quality architecture and quality public space with an appropriate percentage of green space is key to sustainable urban development.

Urban planning and municipal budgets are very closely linked. Few towns or municipalities have an analysis that shows how much a newly developed site will cost in the future and what all will be affected by the development. It is always necessary to include not only capital costs but also operating costs in the consideration of future city expenditures and existing circumstances for a new development or redevelopment area.

It is very important to prepare an urban analysis as a basis for decision-making on future urban planning and the associated minimization of urban problems. Urban planning can be understood as the professional work of guiding urban development through the creation of physical plans and regulations, or more generally as a set of social, economic, environmental, and constructive efforts to make an urban area a better and healthier place to live. Planning, visualization, and spatial analysis are thus an important basis for urban infrastructure planning.

Urban density and sufficient green space are sometimes considered incompatible. However, green space is indispensable even in high-density cities, contributing to public health and quality of life. This value is reflected in property prices around iconic green spaces. High density only works well if it is also in the high quality of both the architecture of buildings and the space between them.

Public space

Open space has been an integral part of urban structures since the beginning of urbanization. Its parameters and form were based on the everyday needs of its users. Open spaces can be divided in terms of ownership or accessibility into public, private and semi-public.

In historic growing cities, public open space was created naturally as an immediate result of needs. Public spaces had transport functions (streets and waterfronts), commercial functions (squares and marketplaces) and relaxation functions (waterfronts, parks and courtyards).

Quality of public space

An important parameter is the quality of the public space, to feel comfortable in a public space, the space must meet certain qualities such as cleanliness, design and facilities. However, due to the financial demands of servicing, only a limited amount of this space can be of this quality. Trash removal, cleaning, care, necessary repairs, and maintenance of green spaces are essential expenses in the city's budget. Consequently, a huge amount of public space is unsustainable and sooner or later will start to degrade. And so, the initially attractive vision of open green space can become an unpleasant place where nobody wants to spend time.

The above shows that there is a correlation between feeling comfortable and the cost of maintaining a space. So, it turns out that the smaller the public space and the fewer resources it costs to service it, the more potential it has to be of high quality.

Intensity of development

To determine the amount of undeveloped space needed, depending on its sustainability over time, we need to determine the ratio between developed and undeveloped space.

Urban density is an important aspect of the functioning of cities; it is the intensity of development and the number of people living in a particular urban area. Density can be determined by different methods according to different factors, each telling a different story, but all relevant to the functioning and sustainable development of a city.

Municipal expenditure can be calculated either per hectare of area or per person. Population density can therefore affect the cost of public services. Population affects municipal costs but also municipal incomes.

Building density

The density of development reflects the ratio between the area of the land and the total gross floor area of the house. The maximum possible density is usually set by law in some locations. The average living area per person varies over time and also varies from country to country. In Germany, for example, the net living area per person is now approximately 35m2 , in Switzerland even up to 50m2 per person.

Population density

Population density is not a completely straightforward figure (compared to e.g., area rates etc.). The same data can often be used to express something different because of the different methods used. Every country does not keep statistics from which population density can be calculated in the same way. Most often, population density is understood as the ratio between the number of inhabitants and the size of the area in which they live. However, this figure only determines the so-called 'night-time' density, i.e., the number of people who spend the night in each area and are also officially registered residents in that place. This contrasts with the so-called 'daytime' density, which is a measure of all the people present in each place at a given time. The calculation of population density must be based on available statistical data. One of these is the number of dwelling units in a particular area. The question then becomes how many inhabitants to count per housing unit. This number varies from country to country and from city to city, but it also varies considerably over time. Structure and typology of buildings

Development structure and building typology

By the structure of the development, we describe a part of the city territory that has certain identical characteristics. We divide them into the growing structure, block structure, solitary villas, small family houses, semi-detached and terraced houses, mixed structure, and modernist housing estates. Building structures differ from each other in their characteristics determined by the number of floors of the buildings, the built-up area, the area use index, the density of the population, the density of the working population and the proportion of public spaces.

Each urban structure (typology) in the city has its own characteristics determined by the character of public spaces, scale of buildings, interrelations, atmosphere. We feel differently in the historic city centre, where there are narrow streets, stone squares, and differently in the outskirts, where large-scale houses are scattered in the park. The different typologies have their positive and negative characteristics in terms of walkability, standard of housing, amount of parks, public facilities etc. It depends on everyone's preferences as to what we prefer, whether we prefer to live in a family house surrounded by a garden or in an apartment in the city centre with access to all facilities.

Different urban structures and types of development have a different ratio between the developed area (houses) and the rest (parks, roads, sidewalks, etc.).The proportion of public spaces reflects the ratio of all public spaces to the area of the site, while the quality and quantity of public spaces contribute significantly to the character of individual sites. In terms of operation and servicing cost, this is one of the most important indicators.

The most expensive structures are modernist housing estates. The high expenditure is due to the large proportion of public spaces, especially unpaved areas. In fact, the spaces of housing estates are characterized by an oversized

public space created based on the modernist idea of living in a park. Compared to the traditional city, where the ratio of public spaces to the whole is around 30 per cent, housing estates have a ratio of 60 to 80 per cent. Such spaces thus represent, for example, higher running costs for the district concerned.

Housing estates

Estimates suggest that about a third of the population of the Czech Republic now lives in prefabricated housing estates.

The urban environment can generally be described as a structure combining developed and undeveloped space. The urban structure of prefabricated housing estates is fundamentally different from that of a traditional growing city. The majority of the area of residential complexes in these settlements is occupied by open space. This predominantly open space between buildings plays an important role in the further development of prefabricated housing estates and is thus an essential tool for their sustainable development.

For the first time in the history of urbanization we are encountering a lot of free public space in prefabricated housing estates that is not intended for a specific function. The looseness of the development was a way to achieve the desired hygienic quality of housing - in terms of sunlight, daylight and ventilation. In the original idea of the garden city, all open spaces were to be used for rest and relaxation, and the prefabricated housing estates were to be peaceful living in green spaces. The attempt to convert quantity into quality through repetition has proved unworkable.

Public spaces are one of the contradictory characteristics of modernist housing estates. But the idea of living surrounded by a park in practice has several flaws. This kind of urbanism creates so many open spaces that it is almost impossible to always make sense of them. The public sector, which is responsible for the maintenance of these spaces, is unable to take adequate care of all the green areas, and so overgrown places or (at best) vast lawns without a concept are created. The vision of a park surrounding apartment blocks has turned into houses surrounded by remnant green spaces with dirty unattended corners. However, open spaces do not belong only to parks. The public spaces of housing structures are a similarly problematic phenomenon. A large number of functionless open spaces. These are paved and unpaved areas, of various sizes and materials, but all are nameless. The areas that have no specific use are just residual areas. We should therefore distinguish between public space and so-called residual space.

Conclusion

Urban density and sufficient green space are sometimes considered incompatible. However, green space is indispensable even in high-density cities, contributing to public health and quality of life. However, it is essential that public spaces are not only accessible and of sufficient size, but also well designed in terms of their size and function, so that residents feel comfortable in them, and they are also sustainable. An important parameter is the quality of the public space, in order to feel comfortable in a public space it must meet certain qualities such as cleanliness, design and amenities. And yet, due to the cost of maintenance, only a limited amount of this space can be of this quality. Public space is of key importance in the lives of residents as it plays a role in both the quality of life of residents and in creating social interaction and connectivity. However, it is important to distinguish between public space, which is used for gatherings and activities of residents, and 'residual' space, which is underused and often neglected. Good planning and care of public space plays a vital role in how a city can manage the dynamic process of densification while maintaining its vitality and attractiveness to its residents.

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3. The Housing Crisis in The Czech Republic and Its Impact On Construction

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Abstract

For several years now, the Czech Republic has been struggling with a housing crisis, which affects the young generation the most. This crisis is the result of a combination of several factors and is also influenced by the history of the Czech Republic. This housing crisis has been deepened by high inflation, rising prices of fuel, building materials and construction work, tightening mortgage loan conditions, high interest rates, the war in Ukraine and the associated arrivals of refugees to the Czech Republic who also need housing here. The response to the housing crisis is the emergence of various alternative forms of housing.

Keywords

housing, housing crisis, real estate market, rental housing, shared housing

Introduction details

In the 1990s, the political and economic situation was changed. In 1993, Czechoslovakia was divided into the Czech and Slovak Republics. In 1994, the Act no. 72/1994 Sb., was adopted (replaced in 2014 by the new Civil Code). The Act no. 72/1994 Sb., allowed the transfer of an apartment into personal ownership. The owner of the apartment, which in most cases was the state (later the municipalities), had to firstly offer the apartment to the existing tenant in the event of a sale. Only after the previous tenant refused to buy the apartment, could the owner of the apartment offer to sell it to someone else. Apartment buildings were transferred to co-operatives, which were made up of tenants of the apartment building. Members of co-operatives could apply for the transfer of the apartment to personal ownership. Co-operative housing experienced a great boom in the seventies and eighties of the 20th century thanks to the numerous constructions of prefabricated apartment buildings. This process, when public property is transferred to private ownership, is called privatization. The state dwelling stock, which was later transferred to the ownership of municipalities, was in poor condition due to low rents. The municipalities did not have much money for their maintenance and reconstruction and therefore there were efforts of the municipalities to privatize the apartments. Privatization was very popular among people because apartments were privatized at a fraction of the market price. It is estimated that up to 80% of the housing stock of municipalities has been gradually privatized. Privatization has also contributed to the development of private housing finance options and banks have started to provide mortgage loans and building savings again. This also supported the numerous constructions of family houses. The following graph shows that since 1991 there have been significant changes in the structure of dwellings in the Czech Republic according to the tenure status. The share of dwellings in private ownership is influenced not only by history, but also by the political situation, the possibility of obtaining a mortgage, the amount of pension, the offer of social housing or the functioning of the rental housing market. A comparable situation occurred in all post-communist countries, which is why dwellings in private ownership dominates in these countries. Rental housing dominates in Western countries.

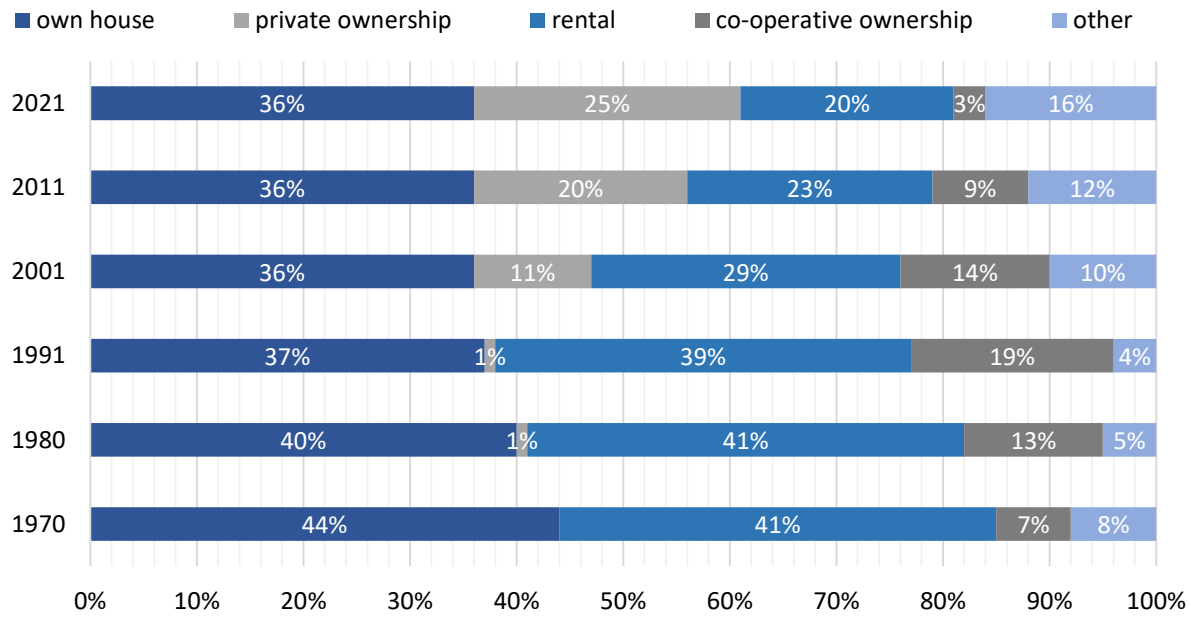

Figure 1: Development of occupied dwellings by tenure status between 1970 - 2021 (source: [1], [2], author)

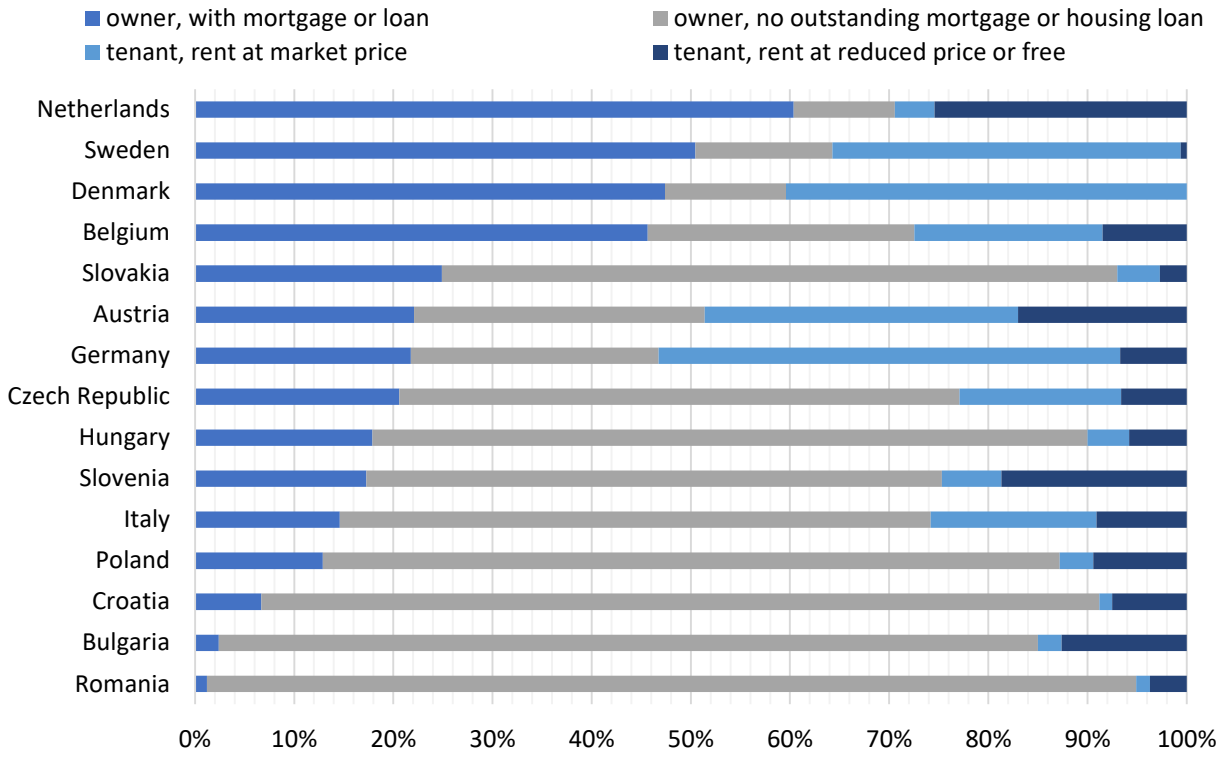

Figure 2: Property by tenure status in Europe in 2022 (source: [3], author)

The desire for dwellings in private ownership still prevails in the Czech Republic. For many Czechs it is almost unrealistic to achieve it. For several years now, the Czech Republic has been ranked among the worst in Europe in terms of the availability of own housing. The worst affordability of own housing in 2022 was obtained by Slovakia, where 14.1 average gross annual salaries are needed to purchase a new apartment with an area of 70 m^2. In the Czech Republic, 13.3 average gross annual salaries are needed to purchase a new apartment with an area of 70 m^2. Compared to 2020 data, the number of average gross annual salaries needed to purchase a new apartment in the Czech Republic has increased by one. The most affordable housing in 2022 was in Belgium. When comparing the availability of housing in individual cities, Bratislava ranked second worst with a need for 14.5 average annual gross salaries, and Prague ranked third worst with a need for 14.2 average gross annual salaries. Rome became the city with the most affordable housing in 2022. [4] [5]

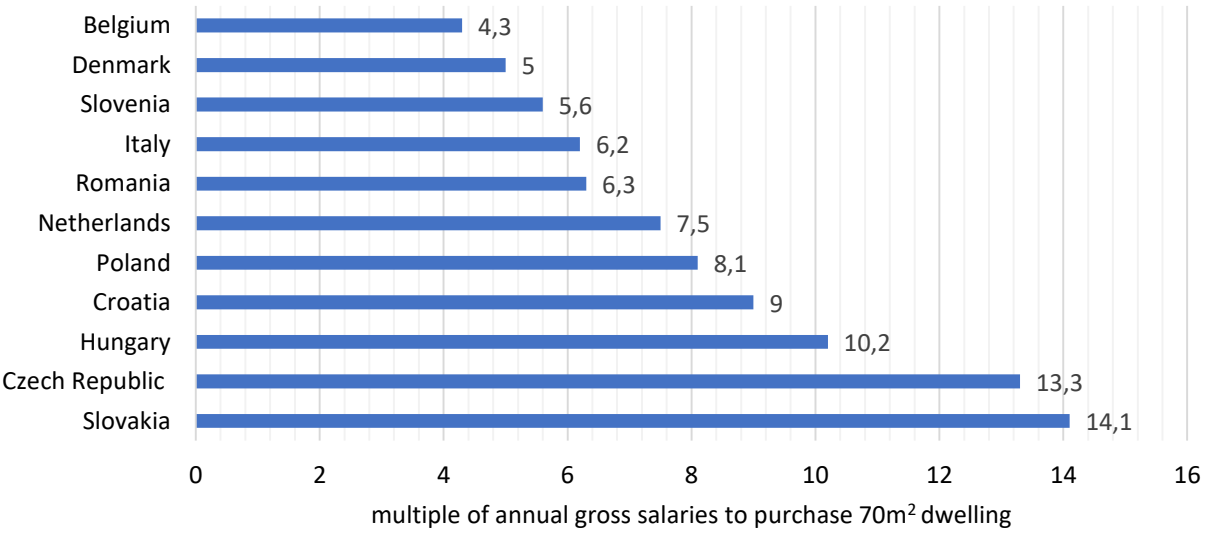

Figure 3: Affordability of own housing in 2022 (source: [5], author)

High purchase prices of apartments in large cities are closely related to the insufficient volume of construction. Experts agree that at least 10,000 apartments need to be completed annually in Prague to bring supply closer to demand. The insufficient volume of constructions is closely related to the long permitting procedure in the Czech Republic, the lack of workers in the industry and the high cost of materials that are in short supply. Around 6,000 apartments are built annually in Prague, and the situation was similar in 2022. In 2022, 39,460 apartments were completed throughout the Czech Republic. However, this number also includes the change in completed buildings, not only new constructions (new constructions amounted to 34 700 dwellings). The highest number of apartments in new family houses was built in the Central Bohemia Region, the least in the Karlovy Vary Region and the Liberec Region. The highest number of apartments in new apartment buildings was built in Prague and the Central Bohemia Region, the least in the Liberec Region and the Ústí nad Labem Region. It is clear from these data that more construction activity is taking place in the largest Czech cities and their surroundings. The lowest construction activity is in post-industrial regions and remote areas. The population leaves these areas for work or education, and as a result, real estate prices are decreasing. The demand for housing in these regions is low, so it is not profitable for developers to invest in new housing. It is the migration of people that increases the demand for housing in large cities and their surroundings. Thanks to data from mobile phones, mobile operators estimate that there are about 300,000 more Czechs living in Prague than the official data shows according to the permanent addresses in their identity cards. This is also one of the reasons why there is a shortage of housing in larger cities. [6] [7]

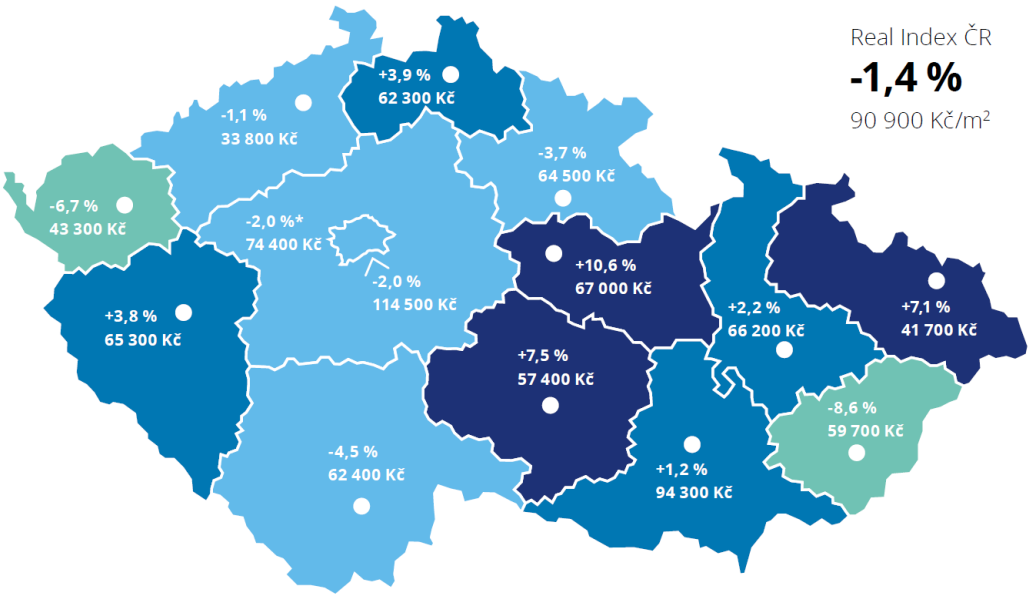

Figure 4: Price per m^2 of realized sales in regional capitals for Q2 2023 and change compared to the previous quarter (source: [8])

At first sight, the Czech Republic has enough apartments, but a more thorough examination of the data from the 2021 Czech Census shows the opposite. The Czech Republic has approximately 10,500,000 inhabitants (people with permanent and temporary residence) and 5,340,033 apartments, which means that there are only two inhabitants per apartment. Unfortunately, the reality is different, as a large number of apartments are uninhabited. 859,894 dwellings were unoccupied in 2021 (this number includes also holiday homes, properties unfit for habitation, redeveloped properties, real estate for short-term rent, etc.), most of them were located in family houses, namely 592,991 apartments. The highest share of uninhabited apartments in family houses was reported by the South Bohemia Region. The highest share of unoccupied dwellings in apartment building was reported by the Karlovy Vary Region and Prague. The highest share of uninhabited family houses was recorded in the South Bohemia Region, the Liberec Region, the Vysočina Region, and the Plzeň Region. For unoccupied apartment buildings, it ranged between 0 and 2% in all regions. Some of the uninhabited apartments are located in municipalities with up to 5,000 inhabitants, exactly 53%. These municipalities make up one-third of all permanently occupied dwellings and two-fifths of the population. There are 4,480,139 occupied dwellings, which is an average of 2.3 people per one of them.

This number varies by region, in Prague it is 2 persons per apartment and in the Vysočina Region it is 2.5 persons per apartment. Despite the fact that this dwelling stock should be enough for the residents of the Czech Republic, in reality it is not due to the currently growing trend of so-called single households. A single household is made up of only one person. Data from the Czech Statistical Office show that out of a total of 4 813 103 housekeeping households, 1 880 336 are one-person households and 1 421 003 are two-person households. These households make up 69% of all. A housekeeping household is made up of persons living together who pay the household expenses together. The highest share of single-person households is in Prague at 47% and in the Karlovy Vary Region at 44%. The lowest share of these households is in the Vysočina Region (33%) and in the Central Bohemian Region (35%). These numbers do not include households in which a single-parent family lives – a single parent living with a child – of which there are another 508,590. Unfortunately, there is no data available on apartments that are empty and unused. [9] [10] [11] [12]

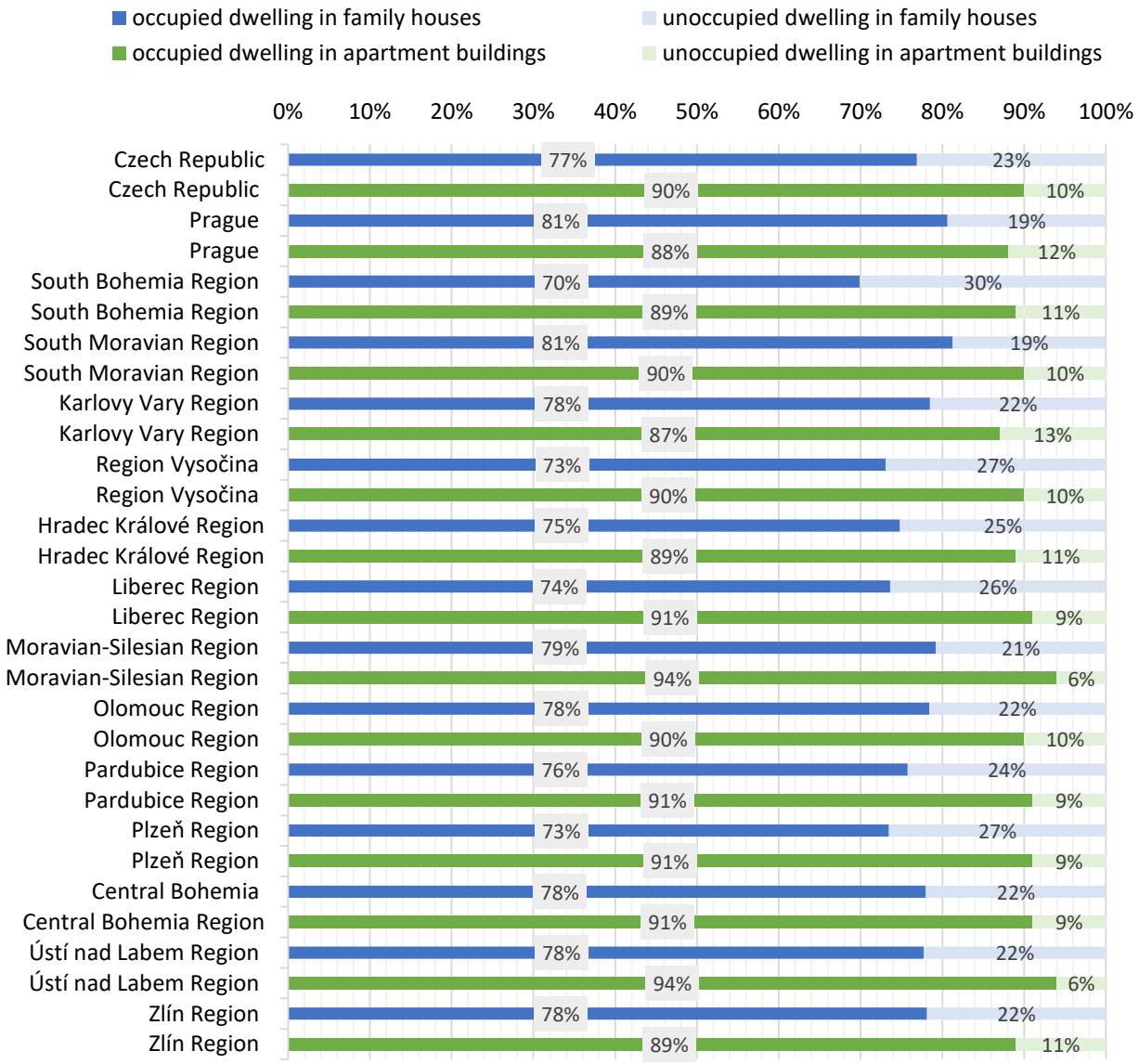

Figure 5: Dwellings by occupancy, type of house and by region (source: [9], author)

On April 1, 2022, the rules for taking out a mortgage loan have become more stricter, which is not conductive to the purchase of own housing. An applicant for a mortgage over 36 years of age must now have a financial amount of at least 20% of the price of the property (change from the original 10%), for people under 36 years of age the original 10% remains. Furthermore, debt-free people over the age of 36 can borrow a maximum of 8.5 times their annual net income, while those under the age of 36 can borrow a maximum of 9.5 times their annual net income. If

a person already has some debts, the ratio of the applicant's total debt over the age of 36 to the net annual income must not exceed 8.5 (for those under 36 years of age it is 9.5). Furthermore, for people over 36 years of age, their monthly repayment of all loans must not exceed 45% of the total net monthly income. For people under 36 years of age, this indicator is reduced to 50%. These new rules apply not only to new mortgages, but also to the refinancing of old ones. Data from the Czech Banking Association show that despite the tightening of mortgage loan conditions and high interest rates, interest in mortgage loans is slowly increasing. A year-on-year comparison shows that the mortgage market is recovering slightly but remains subdued compared to the past. Interest rates continued to decline in September and reached an average of 5.7%, the lowest level in a year. As recently as December 2021, the average interest rate on new mortgages was up to 3%. This growth was influenced by the highest inflation in history, the war in Ukraine and the fading COVID-19 pandemic. In September 2023, 3.5 thousand new mortgages were granted. The average monthly number of newly granted mortgages for January to September 2023 is slightly over 3 thousand, in 2020 the average monthly number of newly granted mortgages was 6.7 thousand, in 2021 9.5 thousand. Mortgages are currently most often taken out for small apartments, one-bedroom apartments with kitchenette and two-bedroom apartments with kitchenette. The average mortgage amount was CZK 3.18 million, the highest average mortgage was CZK 3.46 million in November 2021. [13] [14]

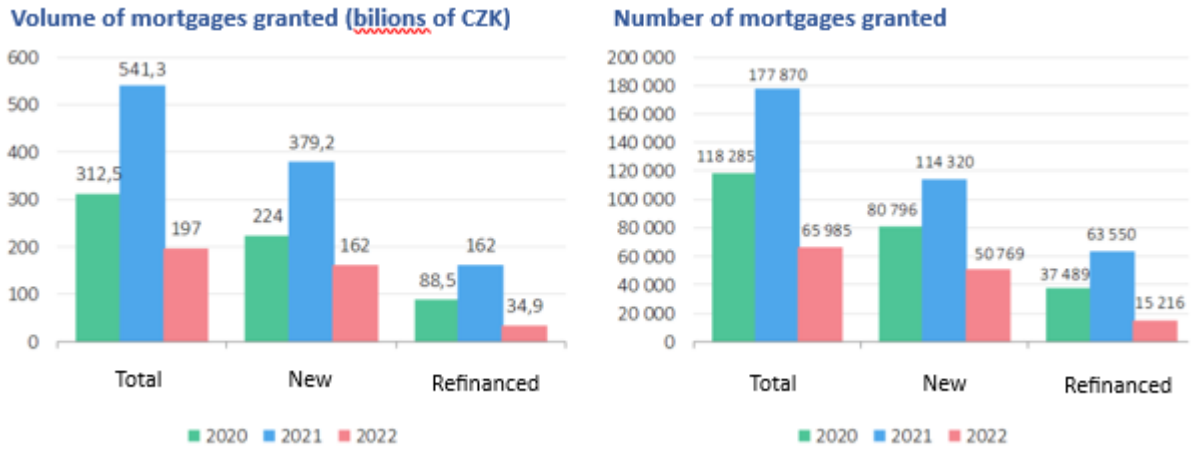

Figure 6: Annual volume and number of mortgages granted between 2020 and 2022 (source: [14])

Demand for rental housing is increasing due to high property prices, housing shortages and expensive mortgages. The war in Ukraine and the associated arrival of refugees who also need housing are also reflected in the growing demand for rental housing. The demand prevails mainly among the young generation and young families who already want to become independent. With higher demand, the price of rent also increases, mostly in large cities. Tenants pay an average of CZK 15,000 for an apartment in Prague with a size of around 40 m^2. The exact amount depends on the location, the age of the apartment as well as whether the apartment is furnished or not. The highest price per m^2 of rental housing is in Prague and Brno, the lowest in Ústí nad Labem and Ostrava. The most sought-after apartments are small apartments. Large developers (Finep, Trigema, Central Group, etc.) are also trying to adapt to the development of the real estate market by changing their residential projects and switching from apartment sales to rental housing. [15]

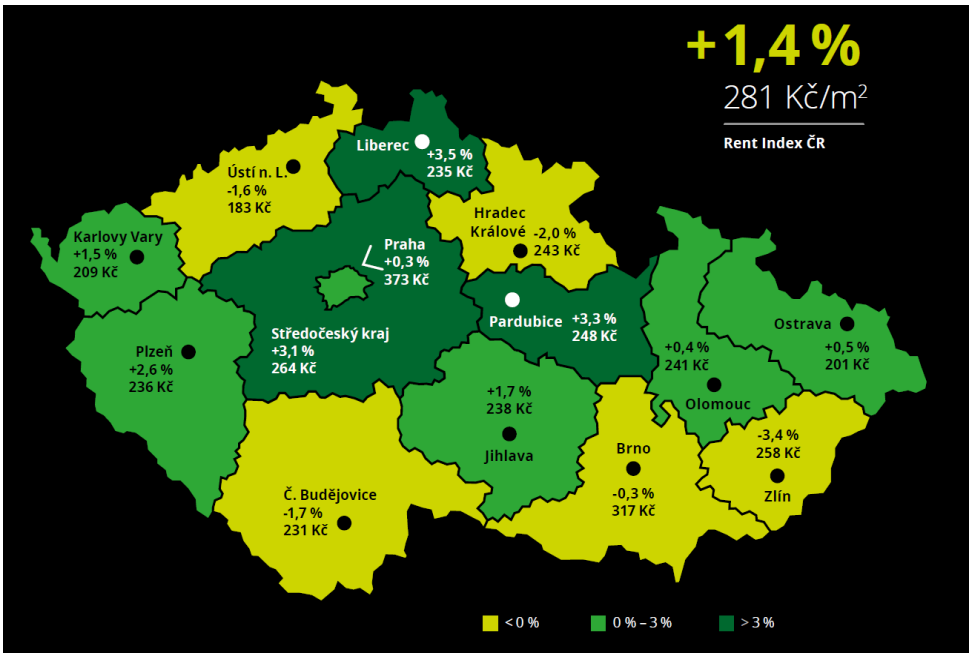

Figure 7: Price per m² of rental housing in regional capitals for Q2 2023 and change compared to the previous quarter (source: [15])

Cities, city districts and municipalities have privatized most of their dwelling stock. They have also sold most of their land that could be used to build rental housing, especially social housing and start-up housing, which is in short supply in the Czech Republic. In large cities, there is an effort to build city social and affordable apartments, but these apartments are growing very slowly. The dwelling stock of the Czech Republic is made up of municipal flats only in a few percent. For example, Prague sold 85% of its dwelling stock during the period 1991 – 2001. By privatizing most of their dwelling stock, cities and municipalities have lost the ability to influence the price of rents on the market. Cities and municipalities can set the amount of rent in the apartments they own. Enough municipal apartments on the market would increase pressure on private landlords. They would not be able to charge absurdly high amounts because there would be no interest in such housing. This scenario works, for example, in Vienna, which has a large number of its own apartments and thus prevents a housing crisis. Vienna offers affordable housing with rent control to all social groups. Regulated rents are twice as cheap as market rents. Applicants for a city rental apartment must meet several conditions, such as a maximum income of €3,200, living in Vienna for two years and being of legal age. [16] [17]

As mentioned in this article, the Czech Republic has a large number of unoccupied dwellings. The number of empty apartments is not directly known. According to Vít Lesák, head of the Affordable Housing Concept Department at the Ministry for Regional Development, there are still 190,000 apartments in the Czech Republic that are truly uninhabited. The large number of vacant apartments has sparked a debate on the Czech political scene about whether these apartments should be taxed more strictly, such as in Vancouver or Melbourne. However, increasing the tax burden on unoccupied apartments has not solved the housing crisis in Vancouver, it has only increased revenues. In Melbourne, the tax did not increase much, so the step did not help to solve the housing crisis. The increase in the tax burden on unoccupied flats should force owners to offer their flats for rent on the real estate market. In the Czech Republic, there was also an idea that the property tax would remain the same for owners of permanently occupied apartments, but unoccupied or permanently unused apartments would be taxed more significantly. This has not been applied, but the property tax will increase to an average of 1.8 times from 2024. The second way to get these empty apartments on the market is to motivate the owners to reconstruct them with the help of a subsidy or a faster permitting procedure and then rent it out. This solution would be faster and less costly than supporting new construction. [18] [19]

Construction should also be affected by the change in the age structure of the population in the coming years. In ten years, the dominant age group will be 50 – 59 years, currently it is 40 – 49 years. The age group of people 40 – 49 years usually has school-age children, so they live in larger and multi-room apartments. The age group of 50 - 59 years is a group of people who will already have grown-up children and will gradually return from large apartments to small apartments. A further increase in single-person households is associated with a greater number of elderly people. Therefore, a significant increase in interest in smaller apartments for purchase and rent is expected. Young and older citizens are likely to have very similar housing requirements in the future. Therefore, a housing model could be created that would bring both of these generations together and could have the effect of alleviating the loneliness of the elderly. Seniors are expected to be able to live longer in their own homes and not depend on care in specialized facilities thanks to constantly evolving and improving technologies. The study from Savills also predicts an increase in the number of people living in cities worldwide. In the Czech Republic, the occupied dwelling stock consists of almost 80% of apartments with 3 or more rooms. The average number of rooms per occupied dwelling is 3.9. These numbers are influenced by the large number of apartments in family houses. The situation is similar in occupied apartments in apartment buildings. Almost 70% of the occupied dwelling stock in apartment buildings consists of apartments with 3 or more rooms. The average number of rooms per occupied apartment is 3.3, the lowest is in Prague with a value of 3.0. In 2022, 14,203 apartments were built in apartment buildings in the Czech Republic, of which 42% were 2+1 apartments, 24% were 3+1 apartments and 18% were 1+1 apartments. Completed apartments in 2022 had an average living area of 49.2m^2 and a usable area of 67.0 m^2. A similar distribution of newly built flats has been going on for about the last 15 years. [20] [21] [22] [23]

The housing crisis is not only in the Czech Republic, but also in many other European countries. In response to the housing crisis, alternative forms of housing are emerging. Among the most well-known are shared housing (co-living and cohousing), container houses, mobile homes, houseboats, yurts and houses on wheels. Shared housing, also known as community housing, emphasizes meeting people and good neighborly relations. Within cohousing, each household has its own apartment or house with all amenities, including a bathroom and kitchen, but there are also common areas (common rooms, garden, kitchen and playroom) that can be used by all residents of the community. Various social events are held in these common areas – cooking, lectures, film projections, etc. The advantage of this form of housing is the support of social contacts, residents of different ages, mutual assistance (support for the elderly, babysitting, etc.), shared facilities and long-term housing. Cohousing is very widespread in Denmark, but it has not yet found popularity in the Czech Republic. Cohousing is well usable for the housing of seniors who would have houses or apartments and then common areas. This would help them to reduce their social isolation. Senior cohousing could be an option to cope with an ageing population. Another type of shared housing is co-living. In co-living, people live in a private room and the rest of the facilities are shared (bathroom, kitchen, living room, playroom, gym, etc.). In some places, there are also forms of a private room with a bathroom, or even a kitchenette. The composition of households within co-living is often focused on a certain group of inhabitants – filmmakers, travelers, etc. Co-living is mainly used by the younger generation and people who travel a lot and work on their travels at the same time. The advantage of co-living is minimizing social isolation and saving on housing costs, but the disadvantage can be a loss of privacy and greater turnover of people (co-living is also rented for a short time). [24]

Conclusion and discussion details

The housing crisis has been an actual topic in the Czech Republic for several years. Privatization of most municipal dwelling stock has resulted in a shortage of social and starter housing. Through privatization, cities and municipalities lost the ability to directly influence the price of rents on the market. Enough municipal apartments on the market would increase pressure on private landlords. They would have to adjust the rental price to the market, otherwise their apartment would remain empty and the owner without profit. The vast majority of apartments on the real

estate market are offered at market rents. Towns and municipalities in the Czech Republic have sold land on which social and start-up housing could be implemented.

People, especially the younger generation, still desire for their own housing, even though the availability of housing in the Czech Republic is one of the worst in Europe. Expensive mortgages are forcing people into rental housing. Rental housing is only temporary for them until mortgage rates and housing prices come down again. This is also related to the amount of the pension. The amount of pension for most seniors in the Czech Republic would not even cover the monthly costs of housing. If the pension system does not change, dwellings in private ownership will continue to prevail.

People do not want expensive mortgages and therefore the interest in buying flats is decreasing. The increase in the price of building materials and works is leading some developers to postpone projects and only complete projects under construction. This also reduces the volume of construction that is so important to meet housing demand. A decrease in apartment prices is also related to a greater supply. High demand for housing is mainly in large cities, where people move for work or education.

The Czech Republic would have enough dwelling stock for its inhabitants if at least two people lived in one apartment. The size of the housing stock is insufficient due to the growing popularity of single-person households. An increase in single-person households is expected due to the change in the age structure of the population. The 50-59 age group will become the dominant population group in ten years. The large number of single-person households and their expected growth will also bring an even higher demand for small apartments. These flats account for more than half of the total volume of newly built flats.

A large number of unoccupied apartments were found in the Czech Republic thanks to the 2021 Census. It would be necessary for the Ministry for Regional Development to analyze the exact number of empty apartments. These apartments could partially meet the demand for rental housing. These empty apartments could enter on the real estate market with the help of the state. Positive motivation through the subsidy could induce the owners to renovate these apartments.

This analysis shows that if the trend of so-called single households continues and goes to the extreme where every adult wants to live alone, the dwelling stock will have to contain 8,500,000 apartments, which means that it will have to almost double. Currently, there are 5,340,033 dwellings in the Czech Republic, and 4,480,139 occupied dwellings. One-third of young people between the ages of 18 and 29 live with their parents, of whom there are just under 1,360,000. In this generation, one-person households predominate, so if everyone wants to become independent and live alone, 445,000 apartments are needed for them. More realistically, some of these people choose to live alone, and some choose to live as a couple. If people who are currently looking for housing are taken into account, the minimum number of apartments to meet demand will be around 4,680,000 apartments.

Currently, there is a great interest in rental housing. This is only a result of expensive mortgages, a shortage of apartments on the market, as well as very high real estate prices. In the Czech Republic, rental housing will not expand as it does in Western countries, mainly because of the pension system. In Western countries, seniors have higher pensions that are able to cover their monthly housing costs and can therefore live their entire lives in rental housing. This is not the case in the Czech Republic, and unless at least there is a change in the pension system, everyone who thinks about their future will want to live in their own home. Therefore, for most people in the Czech Republic, rental housing takes the form of temporary housing only for a few years until one saves up and applies for a mortgage loan for one's housing. Currently, people are waiting for cheaper real estate and lower interest rates. It is possible that the next generation will be forced to live in rental housing due to the poor availability of their own housing, but there will still be a desire to live in their own. Rental housing could develop more in the Czech Republic if municipalities and towns started to invest more and build their own apartments, where they would set their own rents below the market rent.

In the future, shared housing could solve two problems at the same time. The first is the lack of starter housing for young people, and the second is the ageing population and the need for smaller apartments. Younger people do not earn much money, while retirees try to save it. The units themselves would include only the essentials and would be smaller. Common areas would be used for other activities, which would be taken care of by the tenants themselves. They would consist of rooms that would be used by both generations. Shared housing could help these generations reduce housing costs and increase social contacts within the common areas of the building. These generations could also help each other. In the Czech Republic, this type of housing evokes memories of the past and so-called collective houses. That is why this type of housing arouses interest especially among the younger generation, who did not experience this period. Czechs are individualistic and do not like to make contacts with people they do not know, so renting in shared houses would have to be long-term. Thanks to these facts, there will be no mass construction of these houses, but most likely only hundreds to thousands of apartments.

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4. Designing A Survey On Decision-Making in Sustainability in Architecture: Multidisciplinary Approach

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Abstract

This research paper describes a multidisciplinary approach to develop a survey methodology for evaluating decision-making in sustainability within architecture. Collaborating with a sociologist, the survey design benefits from diverse perspectives. The methodology combines quantitative surveys and qualitative interviews with respondents. Surveys provide structured data, while interviews offer insights into the motivations and challenges surrounding sustainability decisions in architecture. This mixed-methods approach ensures a comprehensive understanding of the complexities involved in sustainability choices within architectural practice.

Keywords

Architecture; multidisciplinary; real estate; sustainability; survey

Introduction

Buildings and their operations are responsible for 37% of CO2eq emissions globally according to the United Nations Development Programme [1]. Given the EU's current targets of achieving carbon neutrality by 2050 and all new buildings to be zero-emission by 2030 [2], the topic of decarbonization and adaptation of buildings is crucial.

Currently, the topic of building sustainability is received ambiguously among building and architecture professionals. Many are actively advocating the design of sustainable buildings, but everyone has a different perception of sustainability. Others are skeptical about the topic and see efforts to reduce carbon footprints as misguided or unnecessary. Still others have no strong opinion and not enough information on the topic. There is currently a lack of data on the state of know-how on sustainable building design and construction among professionals.

This research paper describes a design process of a survey among professionals in architecture, real estate and construction that explores perceptions of sustainability. The target groups of this survey are architects, urban planners, landscape architects, real estate developers, investors, academics, consultants and students in these fields. The questionnaire will explore various aspects and criteria of sustainability: environmental, economic, social and cultural, and the respondents' relationship to the topic.

Methodology

To create the proper methodology of the survey, a multidisciplinary team has been established including team members with diverse expertise: a researcher in sustainability in architecture, a sociologist, a user-research expert, students of architecture and a team for the survey distribution and marketing. In this team, multiple steps have been taken to prepare the survey. This collaborative effort aimed to ensure a well-rounded and informed survey design that could account for the diverse aspects of sustainability in architecture.

The design process took into account these steps and topics:

- Review of other surveys
- Goals of the survey, hypotheses
- Target group specification
- Name and description of the survey
- Questions in the survey
- Distribution of the survey
- Qualitative interviews – respondent selection
- Qualitative interviews – questions

The systematic approach, supported by a diverse team and thorough preparations, aimed to develop a comprehensive survey method to better understand the complex field of sustainability in architecture.

Results

Review of other surveys

The initial phase of the survey methodology involved a comprehensive review of existing surveys and research instruments. This step was essential in gaining insights into established practices and pertinent themes in the field of sustainability within architecture. By examining prior surveys, the research team could identify what had been done successfully in the past and determine which areas required further exploration. This systematic review served as a foundation for creating a survey instrument that incorporated best practices while also addressing any gaps or limitations identified in earlier research.

There were relevant surveys about approach of facility managers to sustainability which were published in scientific journals. [3] [4] These surveys included less than 300 responses, and they were not performed on a

representative sample because of the narrow target group. Research in of the articles was done as a questionnaire with 251 respondents. [3] The second research was done in the form of in-depth interviews on the sample of 37 respondents. [4]

In the Czech Republic, only non-scientifical surveys were discovered: interviews with architects as part of the ClimArchiNet project by the Passive House Centre which included ca 10 in-depth interviews. [5] There was a survey among architects conducted by the Sustainability Initiative Group in the Czech Chamber of Architects in 2021. [6]

A survey among real estate investors and their perception of sustainability was performed by the author of this article and published in 2021. [7] The results of this survey were used in the preparation of this more extensive survey,

Goals of the survey

Several research questions were set in the multisciplinary team:

- What do the target groups perceive by the term "sustainability" in architecture and construction?
- How do they perceive the importance of the pillars of sustainability: environmental, social, economic, (cultural) - the question is whether this is essential for the research.
- What areas and solutions are most important to them: for example, carbon footprint, energy savings, water savings, housing affordability, aesthetics, financial return, etc.?
- What is their relationship to sustainability: do they see it as an opportunity, or do they have a negative relationship?
- What opportunities and barriers do they see in implementing sustainability in their projects?

The aim is to compare how these responses vary between different target groups and across different demographics. The results of the questionnaire can continue to be used by different non-profit or educational institutions to design educational programmes or services for different target groups.

The next steps in the design process were set to provide answers to these questions.

Target group specification

The relevant target group was discussed, and it was decided to target a wide array of professionals and students in the fields of architecture and construction. The following fields are targeted: architecture, planning, landscape architecture, real estate development, private owners of buildings, teachers of these fields at universities, consultants and other people who influence the construction of buildings and their surroundings.

The goal is to obtain 1000 answers. However, according to the sociologist the sample cannot be representative, as the target group is quite narrow. Therefore, it is not necessary to achieve 1000 answers, but a sample of 200-300 answers should be enough to compare the answers.

Name and description of the survey

There was a discussion among the name of the survey. Two possibilities were presented: to name the survey with the word “sustainability” in it, or not to include the word. It was decided that the word “sustainability” in the name of the survey would affect the respondents willingness to answer the survey: it is probable, that only people who have a positive attitude towards sustainability would participate in the survey. Therefore, it was decided that the name of the survey will be Trends in Architecture and Construction, to avoid bias of the respondents. It is expected that more respondents will participate in this survey thanks to more general name. It is also expected that there will be more respondents with neutral or negative approach to sustainability, and that it will lead to more diverse responses.

Questions in the survey

The questionnaire contains both quantitative and qualitative questions and it is designed in consultation with a user research expert and a sociologist. The questionnaire explores different aspects and criteria of sustainability:

environmental, economic, social and cultural, and the respondents' relationship to the topic. The questions and sustainability topics were selected based on a scientific article by the author [8] and from other sources such as Sustainable Development Goals by United Nations [9], Level(s) by EU [10], Green Building Rating Systems: LEED [11], BREEAM [12], DGNB [13], SbToolCZ [14], WELL [15].

The structure of the questions is the following:

- Open questions: what trends the target groups perceive, what they perceive as sustainability, what areas or sustainable solutions are important to them - what they spontaneously think of
- Choice of options, rating the importance of the sustainability areas
- Relationship to sustainability: scale, barriers, opportunities
- Demographics: region, profession, gender, age
- Contact: in case they want to send results or participate in an in-depth interview
- Space for comments or suggestions

Distribution of the survey

The questionnaire will be distributed thanks to the contacts of the project researchers to private companies, academic institutions, non-profit organizations, professional networks and online groups, to associations such as ČKA or ČKAIT. Geographical diversity will be taken into account to represent companies and institutions from all the regions in the Czech Republic.

Qualitative interviews – respondent selection

The respondents for in-depth interviews will be selected from the respondents who completed the survey. To ensure a well-rounded perspective and representative sample, a purposive sampling strategy will be employed. This approach involved identifying individuals with diverse backgrounds, roles, and experiences related to sustainability in architecture. By intentionally choosing respondents with varied insights and roles within the architectural sphere, the research aimed to capture a comprehensive understanding of decision-making in sustainability.

Qualitative interviews – questions

The questions for the in-depths interviews will be created after analyzing the results from the survey to be able to cover the topics which were repeatedly mentioned spontaneously by the respondents. The questions will be designed to elicit in-depth responses and insights. They will encompass a spectrum of topics, including the factors influencing decisions related to sustainability, perceived benefits and drawbacks of sustainable practices, and the impact of social and economic considerations. Additionally, the interview questions sought to uncover the unique perspectives and experiences of the respondents, enabling a more profound exploration of their individual journeys and the contextual nuances of their decision-making processes.

Conclusion and discussion

In developing a survey methodology to assess sustainability decision-making in architecture, the research began by reviewing existing surveys, revealing limitations in previous studies. While some surveys existed, they often had limited scope and lacked representativeness. In the Czech Republic, surveys were primarily non-scientific.

The study's goals were set, focusing on perceptions of sustainability, the importance of sustainability pillars, and specific preferences within architecture. A diverse target group, including professionals and students, was selected. The survey was named "Trends in Architecture and Construction" to encourage unbiased responses. It features both quantitative and qualitative questions and explored various sustainability criteria. The survey will be widely distributed through academic institutions, professional networks, and online groups.

Qualitative interviews will be conducted with selected survey respondents to gain deeper insights. These interviews will focus on topics that frequently emerged in the survey responses.

In summary, this research methodology employs an interdisciplinary approach to understand sustainability decision-making in architecture better.

The survey will be distributed in the following months, and the results will be published in a peer-reviewed article.

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5. Case Study: Housing Availability in Prague

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Abstract

This article deals with the situation where four listings for apartments in Prague are found and compared. Prerequisites when searching for real estate are identical entry conditions – total price, personal ownership and the presence of elevator. As part of this research, other conditions and factors that influence the price of real estate are subsequently compared. Factors such as the technical condition of the property, location, economic affordability, transport accessibility (time required to travel to the center and to the edge of the city) and the availability of civic amenities (public transport, shops, restaurants, etc.) are assessed. These aspects are assessed for four apartment units found, which are sold for the same price of CZK 4,800,000 and are located in the following city districts - Zličín, Nové město (center), Krč and Háje. Properties are described from a technical point of view based on photos from real estate companies that are part of the advertisements. The housing units are in their original condition, from renovated units to new construction. The availability of civic amenities is based on the current state according. In the case of economic and transport availability, the assessed conditions can be changed - loan repayment period, mortgage amount and type of household. Within the scope of transport availability, the type of means of transport or the route may change. The aim of this work is to compare locations in Prague with properties offered at the same high offer price. After a local investigation and overall evaluation, property No. 1 in Prague 4 – Krč comes out the best. The property is after reconstruction with a garage and excellent time requirements to the center and out of the city. In addition, it will be close to the planned subway station of line D.

Keywords

availability; civic amenities; comparison; housing

Introduction

When buying and selling real estate, supply must always meet demand, just like in all other markets, not just the real estate market. However, the property itself and its immediate surroundings should offer acceptable comfort for its price. In practice, it is the price of the real estate that matters the most, and only then what is purchased for that price. However, it is the economic availability that is assessed first, so that it is immediately clear whether the buyer can afford the given property from his income. On the other hand, it is not possible to count only on economic accessibility, because there are other types of accessibility that have an effect on the price of real estate and the quality of housing. Not only these types of availability can be considered as other factors influencing the price of real estate in a given location and time. These are, energy availability, transport availability, availability of jobs, availability of knowledge of the locality, availability of utility networks and internet connection, presence of civic amenities, technical and technological availability, legislative availability, availability in terms of spatial planning and other investment plans and, last but not least, the availability of the locality from the point of view of gentrification, when the given locality gradually changes with the structure of the population and the economic use of the given place. Many studies calculate models and infer the effects of various combinations of factors on real estate prices.

When evaluating real estate prices and rents in the respective locality, selected local conditions are addressed. An article [1] focusing on the availability of water supply in Guatemala, comes to the conclusion that the rental price decreases by 0.7 % for each day that a water supply outage is recorded. On the other hand, the price increases by 10 % for properties that have the necessary infrastructure and water tanks, to cover supply failures. Every buyer has different expectations from a property, and therefore the models and factors differ in the studies. As part of the analysis in Rotterdam [2], the effect of the view from the window on the price of the property and the amount of rent is investigated, which is again linked to the quality of the local environment. On the basis of photographic records and the use of map materials, 4 categories of views are determined: views of the city, views of parks, etc., views of the wider neighbourhood and, for example, the river, and other views that do not fall into the previous categories. These factors are entered into the hedonic model together with other parameters of the property, while the view from the window is approximately in the middle of the spectrum of the importance of the monitored factors [2]. This study [2] summarizes, among others, other factors that occur in mathematical models, based on several other articles. Not only the rents and prices of housing units are evaluated, but also the availability and price of land, depending on local conditions [3]. Another study [4] deals with an innovative approach for the construction of a real estate price index at the national level in Morocco to cover more substantial local influences. This is again a specific environment for assessing real estate, as not only individual real estate prices differ in this country, but also living conditions in large cities and beyond. In this case, it is necessary not to compare the results, but above all the input conditions for calculations within the research for Prague and the Czech Republic in general.

In this paper, the research is focused on the situation where housing units are offered at the same price, even though their characteristics and surrounding conditions are different. This is not a broad database, but specific cases that are subjected to more detailed research and from the point of view of local investigation. In the article, a total of 4 apartment units found in Prague with the same search parameters on the real estate website are evaluated. The aim of this part of the research is to assess the different locations and evaluate why the overall prices are the same, but the technical conditions and conditions in the given location are different. The locations are compared in terms of transport accessibility, the presence of civic amenities, energy intensity and at the same time supplemented by economic accessibility with regard to possible variants of household composition. The following is a description of the chosen methodology and a presentation of the results of this research.

Methodology

In order to compare conditions in different locations, housing units in the capital city of Prague are selected. The selection of properties is based on filtering on the real estate website Sreality.cz [5]. The input parameters are chosen - the price of the property in the amount of CZK 4,800,000, personal ownership and the presence of an

elevator. From this entered information, four housing units are found, which are also the subject of this article and research.

Considering the average amount of a mortgage loan of CZK 3,184,970 [6] for the entire Czech Republic, the price range for searching for real estate was between CZK 4,500,000 and 5,000,000. First of all, this is an increase due to higher real estate prices in Prague than in the rest of the Czech Republic. Secondly, the increase is due to the search for the sale price of the property and not the sale price of the property in the amount of the mortgage loan, because the limits of the Czech National Bank on granting loans are still in force. During the gradual search for properties, there were several states - no offer advertisement was found, one or properties were found, which for the minimum indicative value was evaluated as a low number or units in the same house of the same size and therefore in the same location. A comparison of locations cannot be considered here. Only for the value of CZK 4,800,000 are found four housing units in different locations. At the same time, this is a number that is less time-consuming even in the context of a local investigation. Data collection took place at the turn of September and October 2023.

Information on price, size, availability, real estate brokerage fee, floor, type of building, energy efficiency of the building, presence of balcony, basement, parking, technical condition of bathroom, presence of household equipment is collected from individual advertisements. From the photos attached to the advertisements, the map and the panoramic monitoring of the environment in the maps, information about the address, the view to the sides of the world, and an assessment of the technical condition of the entire apartment unit as well as the bathroom are added. According to these photos, it can be recognized whether a renovation has been carried out or what interventions are needed for quality living in the unit. The ad also shows the distances to the nearest amenities to determine the availability of these amenities. These distances are compared for individual units within a radius of 250 m, 500 m, 750 m, 1,000 m and over 1,000 m. The number of civic amenities in a given radius is always correlated with prices per square meter, which differ from total prices. Maps are also used for route planning, from which the distances and time required to reach the centre of Prague (Wenceslas square) are recorded, on foot, by car and by public transport. Distances to highways for leaving the city are also compared as part of transport accessibility.

As part of economic affordability, the mortgage repayment is calculated on the basis of the repayment schedule for different maturity periods and annuity repayments, according to information on the average annual interest rate for new loans [6]. Annuity payments are compared with the average gross salary in Prague, which is updated to the 2nd quarter of 2023 [7]. The following is information about the results of this research.

Results

The four apartment units found are offered identically for CZK 4,800,000 and the legal form of ownership is personal. The buildings have an elevator. Neither unit has a loggia. This describes identical aspects of the properties found. The following is a description of the different properties of the properties and their surroundings. Parking is always possible in front of the house, in some cases within residential parking zones. Apartment No. 1 and 2 include a parking space in the garage. At the address of apartment No. 1, there is a price offer for the purchase of a garage space in the amount of CZK 550,000 [5], which adds to the attractiveness of the given property. The location of the housing units within Prague is shown in Figure No. 1. Three housing units are located more on the outskirts of the capital city and one unit right in the centre. The locations differ in a few cases, which are described in more detail below under the respective availabilities.

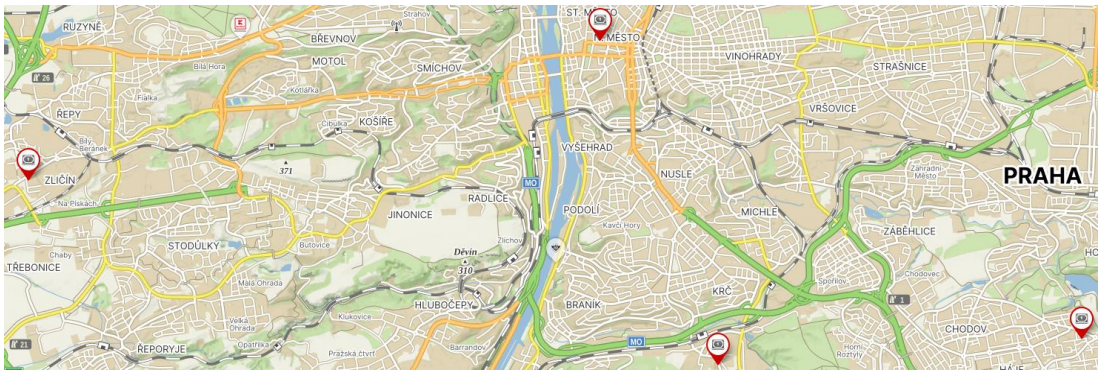

Figure 1: Location of housing units (source: author with use of [8])

The housing units are located in different types of houses, namely in panel houses, new construction and in old brick buildings in the centre. Panel houses and a house in an older building have been renovated and modernized, bringing them closer to the conditions in a new building. In three cases, the apartments have been renovated or at least the bathrooms have been renovated. Only one apartment in the panel building is in its original condition, suitable for complete reconstruction (apartment no. 4). Each of the apartment units is offered by a real estate agency. However, only two state that the commission of the real estate agency is included in the total bid price. In Buenos Aires, a law was passed to limit commission fees to tenants, so landlords bear this obligation [9]. On the other hand, the assumption that landlords project this cost into the amount of the rent has been confirmed, thereby spreading the commission over the contracted rental period [9]. On the basis of this article, it can be concluded that this fee is included in the offer price even for the housing units monitored here, where no commission is mentioned.

Property No. 1 is located in the Prague 4 – Krč district near the hospital. Traffic is very busy here, due to the connection to the city ring road and the large number of prefab houses within the housing estates. The road leading from the suburbs passes through this part of the city. There is also the original development of older family houses, but only on smaller territorial units. Due to the larger number of residents in the housing estates, there are schools and kindergartens that can be reached on foot or by regular public transport connections. The construction of the new metro line D will also help improve urban transport.

Unit No. 1

Figure 2: Photo of apartment unit No. 1 (source: [5])

Picture No. 2 shows photos of the available 2+kk apartment with an area of 40 m^2. The apartment unit is located in a panel building and is in very good condition, where no intervention or direct reconstruction is necessary in order to live in the apartment. Here, it really depends mainly on the subjective opinion of the buyer on the colour of the walls and the equipment of the bathroom. According to other available photos, the panel house was modernized, including elevators, technical equipment of buildings and electrical distribution in common areas. The apartment unit does not have a balcony or a cellar or storage room. The view from the apartment is oriented to the south. The offer price also includes a garage located in the basement of the house. The value of such a parking space was listed

at CZK 550,000 [5] among the advertisements. The apartment unit is offered including equipment and custom-made furniture.

Property No. 2, shown in Figure No. 3 below, is a new building that was approved in August 2022 and is located in the Zličín district. The new building is located in a locality with family houses or other smaller new buildings. The property is located near a large shopping centre at the exit from Prague on the D5 highway and the terminus of the metro line B. Also due to the presence of a bus and train station, it is a very good transport accessibility, which is discussed later in this article. However, this is a locality with a smaller area of parks, nature and other historical or natural elements. The proximity of Václav Havel Airport is more noticeable here and could deter some buyers from purchasing such a property. The property is sold by a real estate agency and not directly by the developer. Therefore, the offer price can be considered as the price without value added tax. The truth of this assumption is evidenced by common practice in new construction, when the kitchen unit is not part of the apartment unit, because the buyer arranges it himself.

Unit No. 2

Figure 3: Photo of apartment unit No. 2 (source: [5])

Standard materials are used in the mentioned property No. 2, which are commonly used in the construction of apartment buildings. It is not above standard, which corresponds to the price of the property. Only construction costs for housing units using above-standard materials can easily reach up to CZK 120 - 150,000 per 1 m^2 these days. The total price of the apartment subsequently includes other investment costs. The apartment unit is immediately ready for living as soon as it is furnished. This condition is identical to property No. 4. The view from the apartment is oriented to the west. The unit has a cellar and a balcony. The habitable area is thus reduced from the total usable area to 28.8 m^2. This is the only property to which a cellar and a balcony or loggia are associated at the same time. The apartment unit also includes a garage parking space. The offer price of similar properties was not found.

Property No. 3, which is shown in the photos in picture No. 4, is located in the city centre and therefore in the Prague 1 – Nové město district. It is a historic apartment building with a decorated, reconstructed facade. Due to the narrow streets, there are bigger problems with parking, which is also possible only in defined residential zones. Due to the location of the house, the city centre, higher noise and street pollution can be experienced here. Tourism can be considered the main reason. The availability of public transport and parks (Karlovo náměstí) can be assessed as the best of the units listed here. Similar to apartment No. 1, there is a hospital close to this property.

Unit No. 3

Figure 4: Photo of apartment unit No. 3 (source: [5])

The whole house has been renovated, as well as the mentioned apartment unit. The entrance to the apartment unit is located on the 1st floor. However, part of the usable area is located in the basement. The view therefore faces east, but there can be no daylight in the unit for technical reasons. Precisely because of the location of the apartment unit, security cameras and security grills are installed here, the acquisition costs of which must be taken into account in the offer price. The premises have basic equipment from the current owner. Operating costs are also affected by the presence of reception and security, not only by the worst energy efficiency among the assessed properties.

Property No. 4, which is shown in picture No. 5, is located in the Prague 11 – Háje district. Its location resembles the location of apartment No. 2, which is also located near the final metro station. Apartment No. 4 is, however, located near the terminus of the metro line C. The park and the Hostivař water reservoir can be reached near this property. Greenery is also spread between individual apartment buildings. It is a quiet location with low incidence of noise. The highway and railway pass at a sufficient distance from this apartment unit. Unlike real estate in the Zličín district, there are no large shopping centres available here. There are no designated parking zones in this part of the city, but there are plenty of parking spaces.

Unit No. 4

Figure 5: Photo of apartment unit No. 4 (source: [5])

The apartment unit is in its original technical condition, i.e. with a umakart core and original kitchen unit. However, in a revitalized block of flats. On the other hand, the original electricity distribution and plumbing distribution must be changed or completely reconstructed. It is considered appropriate to reconstruct the floors with the inclusion of at least underfoot insulation and waterproofing in the bathroom. The apartment unit is definitely habitable. However, for modern living and comfort, it may not suit buyers now, as higher future operating costs or investments are hidden behind this unit. Compared to other apartments, this unit is in the worst technical condition and at the same time does not have a parking space. This is the least advantageous property, also in terms of transport accessibility to the center.

All information regarding housing units 1 – 4 is summarized in table No. 1 below. Although the total price is not comparable, also due to the input parameters, it is interesting to observe the price per 1 m^2. It varies depending on the size of the unit. The correlation coefficient is equal to -0.999. The smaller the usable area, the higher the price per 1 m^2, regardless of other monitored aspects.

Table 1: Information about housing units (source: author with use of [5])

	Price	*Area [m^2]*	*Price per 1 m^2*	*Brokerage*	*Layout*	*Material*
1.	CZK 4,800,000	40	CZK 120,000	not specified	2+kk	prefabricated
2.	CZK 4,800,000	40	CZK 120,000	included	1+kk	brick
3.	CZK 4,800,000	30	CZK 160,000	not specified	1+kk	brick
4.	CZK 4,800,000	41.5	CZK 115,663	included	2+kk	prefabricated
	Technical status	*Balcony*	*Basement*	*Parking*	*Floor*	*Bathroom*
1.	very good	-	-	garage	15	brick
2.	new construction	5.5 m^2	5.7 m^2	garage	3	brick
3.	after reconstruction	-	-	on the street	1	brick
4.	original state - good	-	1.2 m^2	on the street	2	Umacart core
	Equipment	*View*	*Energy label*	*Adresa*		*MČ*
1.	included	South	C	Štúrova 1701/55		Prague 4 – Krč
2.	in part	West	B	K metru 227/8		Prague 17 – Zličín
3.	included	East	D	Příčná 1892/4		Prague 1
4.	in part	South	C	Plickova 569/7		Prague 11 – Háje

Precisely because of the strong dependence on the area of the unit, it is possible to compare other attributes of the listed units with regard to the price. As part of energy availability, it is necessary to mention that apartment No. 3 is located in a building with twice as bad energy requirements as apartment No. 2, which is part of a new building. The operating costs of the given units will vary greatly, and therefore from the point of view of total costs, an apartment in a new building is better. The area here is almost identical, so the same area is heated, since the balcony and the basement are not heated. When comparing housing areas, the price per m^2 differs by only CZK 6,666. Living conditions in basement apartment no. 3 and apartment no. 2 on the third floor are very different due to daylight. The basic differences are therefore in the presence of equipment, the possibility of parking and transport accessibility and the availability of civic amenities. There is a minimal difference in price per 1 m^2 between apartments No. 1 and No. 4. This is caused by the presence of a chamber in apartment No. 4. The fundamental difference is visible in the technical condition of the unit and the presence of a garage, which with its price of approx. view and both are located in prefab houses. In apartment No. 4, reconstruction is necessary before moving in, because moisture is often trapped in the umakart cores, especially in smaller apartments where high-quality ventilation is not possible. The costs of reconstruction can then vary depending on the requirements of future buyers, which can also have an impact on the overall operating costs (plasterboard ceilings, floor insulation, heating, electrical installations). The energy availability of all mentioned apartments differs in total operating costs. However, information on operating costs is not available, as are the code of rules of the unit owners' association.

Economic affordability

The initial prerequisites for assessing economic availability can be considered identical for all housing units, as the parameters for the mortgage loan do not change. The interest rate is determined on the basis of the published average interest rate [6]. The amount of the mortgage loan is equal to 80 % of the offer price, which corresponds to the limits for granting loans (20 % equity). In table No. 2, the annuity payment is calculated for different loan durations. In the event that the average gross salary is statistically calculated for the 2nd Quarter of 2023 for Prague in the amount of CZK 52,833, which represents a net salary of CZK 41,656 [7]. For this amount, it is only possible to

provide a mortgage loan for 30 years, and even that is on the edge of the limit set by the Czech National Bank for mortgage providers. The basic question is always assessing the type and size of the household for which the property is being purchased. It can be a one-person household, a two-person household or a smaller family. A higher joint net income, its stability and financial history improves the economic affordability of housing. On the other hand, it is necessary to indicate not only the size and type of the household, but also the purpose of the purchase, which can be considered investment in real estate for the purpose of renting, own housing - e.g. a starter apartment for young people or the acquisition of real estate in order to provide housing for a family member. Economic availability is also assessed from the point of view of the amount of equity.

Table 2: Monthly repayment of mortgage depending on the maturity period and interest rate (source: author with use of [6])

The size of a new mortgage	CZK 3,840,000
Average interest rate	5.74 % p.a.
Maturity of the mortgage in years	*Monthly payment*
20	CZK 26,938
25	CZK 24,134
30	CZK 22,385

Operating costs, costs associated with transport, property taxes, insurance and, last but not least, investment costs or costs of reconstruction, modernization and building modifications. According to article [10], the cost of self-help reconstruction does not include the time of property owners, when comparing market prices for reconstruction from construction companies. Furthermore, the influence of costs for real estate renovations (apartment units, family houses) is discussed as a significant part of home investments in the USA among older Americans [10].

Traffic availability

When assessing transport accessibility, individual modes of transport and the possibilities of reaching the target destinations from the selected property must be compared. For this reason, two routes are chosen – to the centre at Wenceslas Square and to leave the city. It is not only distance that matters, but also time. Using route search in maps [8], distances and time required to reach a destination on foot, by car or by public transport are recorded. Only a car is chosen to leave the city. By leaving the city, we mean the fastest way to the expressway, the city ring road or the highway. All the mentioned information is contained in the following table No. 3.

Property No. 3 is the most convenient for reaching the centre due to its location and distance of 642 m. Despite this, the car's time is the lowest. From these longer distances, the centre can be reached on foot in two to almost four hours, depending on the complexity of the terrain. The difference between apartments No. 2 and No. 4 is only 600 m and approximately 6 minutes. Availability by car ranges from approx. 10 to 20 minutes. However, in the case of traffic accidents and heavy traffic, it can take up to an hour's journey. In the case of public transport, such a fluctuation in the duration of the journey does not manifest itself. On the other hand, apartment No. 1 is the furthest from the subway. For an apartment in the centre, part of the duration is mainly the time for the stop, otherwise the net transport time is approximately 3 minutes. For other apartments, the difference is up to 8 minutes.

Table 3: Distance and time required (source: author with use of [8])

	Distance to the centre (Václavské square) [m]	*Time – on foot [min]*	*Time – car [min]*	*Time – public transport [min]*	*Shortest distance to leave the city [m]*	*Time – car [min]*
1.	8,200	133	13	30	5,700	8
2.	11,400	216	21	34	2,000	3
3.	642	11	5	7	10,000	13
4.	12,000	208	20	38	3,000	5

In the case of availability and time-consuming travel out of the city, the situation reverses and the worst housing unit is the apartment in the center. The best apartment is unit No. 2 located in the Zličín district. Again, it is necessary to mention the changing time depending on the traffic situation (rush hour, weekend, holiday traffic). Transport accessibility varies, however, in the case of a trip to the center, apartment No. 3 is the best choice, and apartment No. 2 when traveling from the city. Transport accessibility is often linked, when assessing the traffic situation, to the civic amenities and the number of visitors to the given locality (shops, company headquarters , monuments and other civic amenities).

Availability based on amenities

Amenities are assessed based on the distance from the property. The scope of the search includes for example – Shop, Patisserie, Restaurant, Cinema, Sports ground, Park or green space, Theatre, ATM, School, Kindergarten, Doctor, Train, Bus stop, Tram, Metro, etc.. Table No. 4 shows the number of civic amenities, always within a certain distance. At a distance of up to 250 m, the most civic amenities are located at apartment No. 3, i.e. in the centre. At a distance from 251 to 500 m, the total number evens out. In the sum of the first two categories of distances, apartment No. 1 comes out the worst.

Table 4: The number of civic amenities (source: author with use of [5] and [8])

Distance	*1.*	*2.*	*3.*	*4.*	*Value*
do 250 m	2	5	10	5	0,879
Od 251 do 500 m	7	7	6	8	-0,869
Od 501 do 750 m	3	2	3	1	0,592
Od 751 do 1000 m	0	1	0	0	-0,285
nad 1000 m	9	6	2	7	-0,894

In the table No. 4 is shown the correlation values between the price per 1 m^2 and the number of civic amenities in the relevant perimeter. The strongest dependence is for the distance up to 250 m, which is the best reachable distance on foot. Other distances have a smaller dependence or a negative dependence – i.e. the higher the price, the smaller the number of civic amenities. An interesting fact is that not a single property has a metro station within 250 m.

Conclusion and discussion

The aim of this article was to assess the locations of the selected properties and evaluate why the overall prices are identical, but the technical conditions and conditions in the given location differ, including the prices per 1 m^2. It was found that the area of the housing unit and the number of civic amenities and their availability within 250 m from the address of the housing unit have the greatest influence. Transport availability, as a whole, does not have a definite effect on the price. However, in a more detailed analysis, the correlation is evident. A higher price per 1 m^2 occurs for properties closer to the centre. On the other hand, the transport distance and the time required to leave the city can be decisive for some buyers. The respective localities Zličín, Krč, Háje and Nové město in Prague have very similar features in certain respects (number of civic amenities within 500 m, distance to exit the city, time consuming by public transport, energy consumption, absence of a balcony). At first glance, the economic availability appears to be identical, given the terms of the mortgage loan. However, the most important thing here is the type of household and the need for real estate - own housing or as an investment apartment for the purpose of renting. When comparing the amount of annuity payments and the average gross salary in Prague, it is evident that property is on the edge of economic availability. From a technical point of view, considering the price per 1 m^2, it is interesting to compare apartments No. 1 and No. 4, because the prices are similar, but apartment No. 1 has a renovated bathroom, apartment equipment and a garage space, while apartment No. 4 there is no parking space and the apartment is in its original condition. Therefore, the presence of other reasons that influence the price is a prerequisite. This is why mathematical models use more variants and more elements entering the calculations. In

general, apartment No. 1 comes out as the most advantageous. The aim of this article can be considered fulfilled with these conclusions for discussion. Information on individual properties sold by real estate agencies is poorly structured and incomplete. For research purposes, it is complicated to obtain the statutes of individual SVJs and operating costs for each unit, as this information is often only given to serious interested parties.

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6. Evaluation of Collisions Within The Project Coordination in BIM – Case Study

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Abstract

This article deals with the use of the BIM model for the overall coordination of a construction project. In particular, projects for the technological equipment of buildings. The hotel reconstruction project in the center of Prague was chosen as a case study. For the purposes of this article, 5 types of collisions were chosen, the occurrence of which is essential for the given project. Using special software, the total number of collisions of the selected types was determined. Furthermore, the collisions were divided into 3 categories according to their impact on the implementation of the project. Finally, the overall coordination was evaluated based on the ratio of high impact collisions.

Keywords

Construction project, BIM, Collision

Introduction

The aim of this article is to evaluate the number of collisions in the coordination of a project design created in BIM, especially a project of technical building equipment. A hotel reconstruction project in the center of Prague was chosen as a case study.

The building was originally completed in the 1970s of the twentieth century. Currently, the entire reconstruction of the building is underway, essentially only the reinforced concrete frame remains of the original construction.

The hotel includes almost 300 rooms, several kitchens, bars and restaurants, wellness, swimming pool, ball room, several conference halls and extensive technical facilities.

According to the contract, the construction is carried out according to classic 2D project documentation, but the coordination of individual technologies is solved in the BIM model. Given that a large number of technologies will be used in the new facility, it is very important that the coordination between them is processed at a high level and that the number of collisions is minimal. [1]

The main problem of successful coordination is the lack of space. The individual floors are relatively low in relation to the number of technologies used and there is very little space within the suspended ceilings. Another major problem is the age of the reinforced concrete structures and their condition, so that many of the required penetrations are subject to detailed static control and often have to be carried out in other places than would be suitable for coordination.

The main technologies used in the building are:

- water supply
- sewerage
- gray water treatment
- well water supply
- retention and treatment of rainwater
- gas
- heating and cooling
- geothermal wells
- ventilation system
- sprinkler system
- high-current and low-current electrical wiring
- fire detection and fire alarm systems

Methodology

To evaluate whether the coordination is successful and usable for construction, the number of collisions is determined. To do so, Solibri Model Checker software was used. [2] For the purposes of this article, 5 main types of collisions were selected depending on the complexity of their resolution. Due to its size, it mainly concerns the collision of ventilation ducts with other types of ducts and the collision of ventilation ducts with reinforced concrete structures. The next least variable pipe system is the sewer pipe system due to the necessity of running in a slope. The selected types of collisions are:

- ventilation ducts X reinforced concrete structures
- ventilation ducts X sewer pipes
- ventilation ducts X heating and cooling pipes
- ventilation ducts X water supply pipes

- ventilation ducts X sprinkler system pipes

The next step is to classify collisions according to their impact:

- Group 1 – low impact collisions
  - Less than 33% of the cross section of the pipes collide
- Group 2 – medium impact collisions
  - Between 34% and 66% of the cross section of the pipes collide
- Group 3 – high impact collisions
  - More than 67 % of the cross section of the pipes collide

In order to evaluate the coordination as successful, it was determined that the number of high impact collisions must be less than 10% of the total number of collisions.

Results

Low impact collisions

Low impact collisions do not have major impact on construction. These types of collisions can be easily solved directly on the construction site by site managers and workers and it is not necessary to involve designers in their solution. Such collisions rarely have an impact on overall coordination.

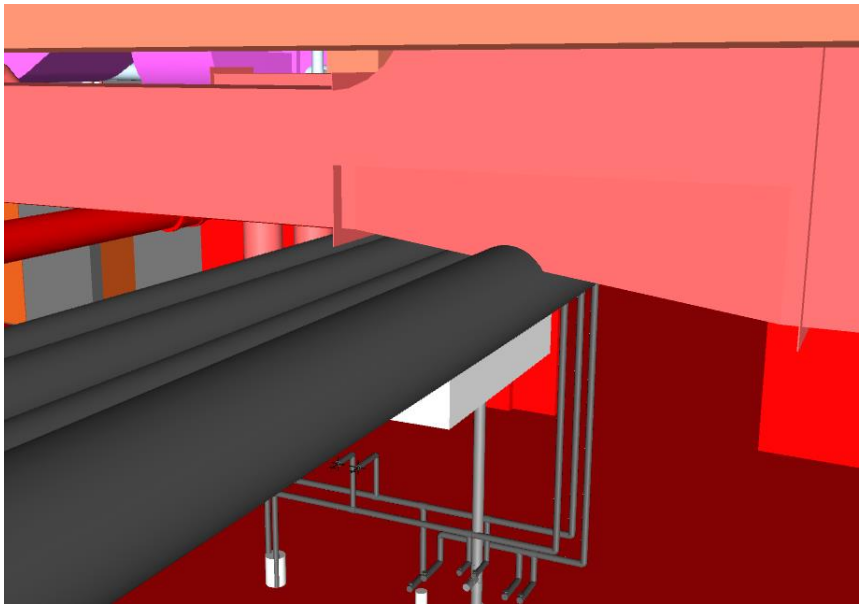

Figure 1: Example of a low impact collision (source: author)

Total numbers of low impact collisions in the model for selected types are shown in Table 1.

Table 1: Low impact collisions groups (source: author)

Type of collision	Number of collisions
ventilation ducts X reinforced concrete structures	93
ventilation ducts X sewer pipes	249
ventilation ducts X heating and cooling pipes	227
ventilation ducts X water supply pipes	379
ventilation ducts X sprinkler system pipes	211

Medium impact collisions

This type of collision can have bigger impact on construction. Its solution mainly depends on the amount of free space around. They can be solved directly on the construction site, but it is more appropriate to leave their solution to the designers of the technologies concerned. On the one hand, because of the possible impact on the functioning of the given technology, and on the other hand, because of the possible impact on the overall coordination.

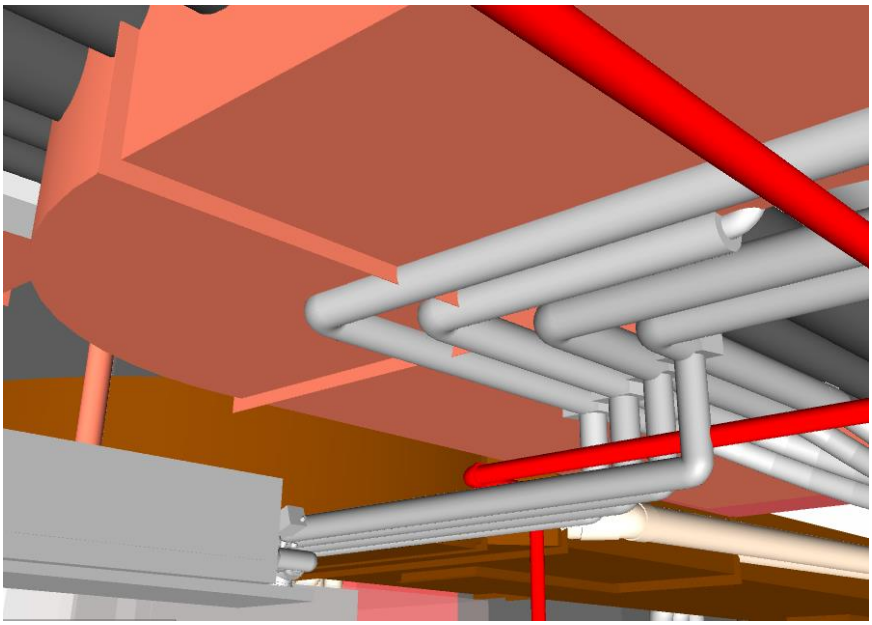

Figure 2: Example of a medium impact collision (source: author)

Total numbers of medium impact collisions in the model for selected types are shown in Table 2.

Table 2: Medium impact collisions groups (source: author)

Type of collision	Number of collisions
ventilation ducts X reinforced concrete structures	112
ventilation ducts X sewer pipes	218
ventilation ducts X heating and cooling pipes	196
ventilation ducts X water supply pipes	173
ventilation ducts X sprinkler system pipes	452

High impact collisions

High impact collisions have a fundamental impact on the realization of the building. Their solution must be left to the designers, because they almost always have an impact on the functioning of the technologies concerned and on the overall coordination. Their solution affects the majority of interested designers and can cause major delays in construction.

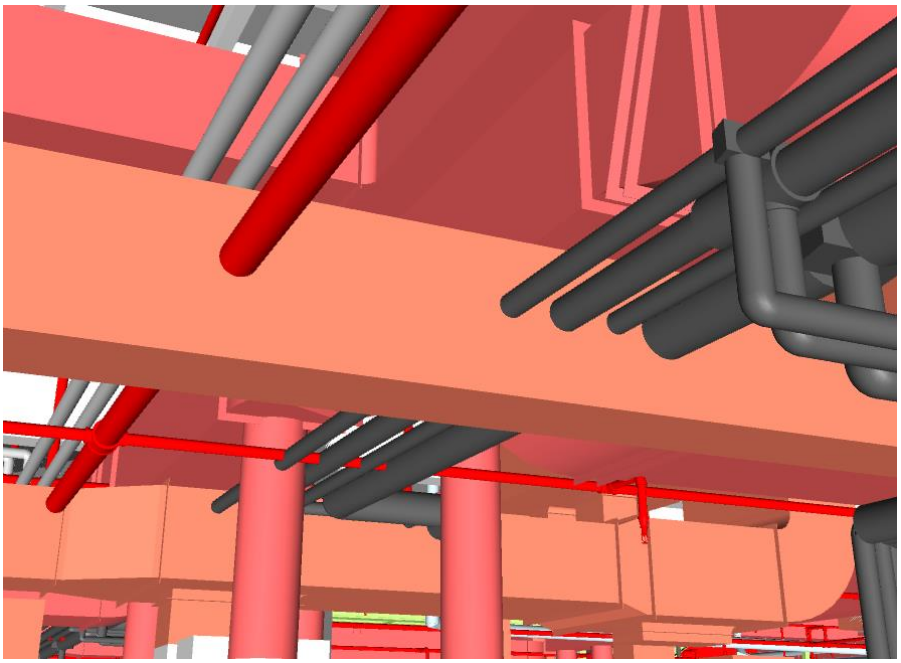

Figure 3: Example of a high impact collision (source: author)

Total numbers of medium impact collisions in the model for selected types are shown in Table 3.

Table 3: High impact collisions groups (source: author)

Type of collision	Number of collisions
ventilation ducts X reinforced concrete structures	202
ventilation ducts X sewer pipes	574
ventilation ducts X heating and cooling pipes	114
ventilation ducts X water supply pipes	92
ventilation ducts X sprinkler system pipes	496

Table 4 summarizes the number of collisions for the selected types, their total number and the percentage of the number of high impact collisions.

Table 4: Evaluation (source: author)

Type of collision	Number of collisions				
	L	M	H	TOT	%
ventilation ducts X reinforced concrete structures	93	112	202	407	49,6%
ventilation ducts X sewer pipes	249	218	574	1041	55,1%
ventilation ducts X heating and cooling pipes	227	196	114	537	21.2%
ventilation ducts X water supply pipes	379	173	92	644	14,3%
ventilation ducts X sprinkler system pipes	211	452	496	1159	42,8%

Conclusion and discussion

To evaluate the coordination as successful, the rate of high impact collisions on the total number was set to 10%. As can be seen in Table 4, no collision type meets this requirement. The ratio for some types reaches almost 50%,

for collisions between ventilation ducts and sewer pipes it is even over 50%. Considering that these two systems were initially determined to be the most essential for the overall coordination, this number of collisions is completely unsatisfactory.

As a whole, the current overall coordination is insufficient, it must be reworked and it is not possible to implement the construction according to it.

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7. Development of Transport Through PPP Projects

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Abstract

In this article we will discuss the concept of PPP projects in the context of transport construction. We will explore what exactly PPP means in the context of transport, and why this form of public-private cooperation is crucial for the development of modern infrastructure. We will also look at examples of successful PPP projects in transport from different parts of the world to better understand the impact of these projects on economic development and improving people's living standards.

Keywords

PPP, transport construction, development, sustainability

Introduction

In the modern world, many countries are facing increasing challenges in transport and infrastructure. With growing populations and economic development, the demand for efficient and sustainable transport solutions is increasing. Public-Private Partnership (PPP) projects have become a key tool for financing, building and operating transport infrastructure projects.

In this article, we will discuss the concept of PPP projects in the context of transport construction. We will explore what exactly PPP means in the context of transport, and why this form of public-private cooperation is crucial for the development of modern infrastructure. We will also look at examples of successful PPP projects in transport from different parts of the world to better understand the impact of these projects on economic development and improving people's living standards.

We will also explore the challenges that stakeholders may face in implementing PPP projects in transport and analyse innovative approaches that can help overcome these obstacles. Finally, we will look to the future and discuss possible trends and innovations in transport PPP projects that may change the way future transport infrastructure projects are financed and implemented.

This introduction provides a glimpse of the main topics we will address in this paper and shows the importance of PPP projects in the context of modern transport planning and development.

What are PPP projects?

PPP projects, or Public-Private Partnerships, are collaborations between the public and private sectors to finance, build, operate and maintain infrastructure projects. In the context of transport, this form of partnership means that the public sector (often government or local authorities) works with private firms (e.g. construction companies, investors) to deliver transport works and services.

The main features of PPP projects are:

- Risk Sharing: the public and private sectors share the risks associated with the project. This means that if there are financial or operational problems, both parties share responsibility.
- Financing: The private sector often invests in the project and bears part of the financial burden. This may include financing the construction and subsequent operation of the infrastructure.
- Quality and Efficiency: The private sector can bring expertise and innovative approaches, which can lead to higher quality and efficiency in the project.
- Long-term Collaboration: PPP projects are usually long-term partnerships that can last for decades. This allows infrastructure and service provision to be maintained over time.

This collaborative model can be applied to different types of transport projects, including road, rail, airport, port and public transport construction. In these projects, the public and private sectors complement each other to achieve a common goal: improving transport infrastructure and services for residents and businesses.

Examples of successful PPP projects in transport

There are many examples of successful PPP projects in the transport sector in different parts of the world that serve as inspiration for other projects and demonstrate the power of this model of public-private cooperation. Here are some examples:

- France: A65 motorway: The A65 motorway linking Langon and Pau was built and operated in partnership with private investors. This project has reduced congestion on existing roads and improved accessibility to the region.
- United Kingdom: Transport for London (TfL): TfL worked with private companies to upgrade and operate the London Underground. This partnership has led to improved services for millions of daily passengers.

- Australia: Tullamarine Freeway CityLink: This project connected important areas of Melbourne and led to improved traffic flows. A private company invested in the construction and operates this important highway.
- India: Bengaluru International Airport: The private and public sectors worked together to build and operate the Bengaluru International Airport. This project brought modern infrastructure to the region and boosted economic growth.

These examples show how PPP projects can improve transport infrastructure, reduce the burden on government budgets and provide efficient services for residents and businesses. Successful public-private collaborations are key to developing modern and sustainable transport networks in cities and rural areas around the world.

Choosing the Right PPP Model for Transport Construction

When implementing PPP projects in the transport sector, it is crucial to choose the right partnership model to suit the specific needs of the project and the stakeholders. There are different PPP models, each with its own advantages and limitations. When choosing a model, it is important to consider the following aspects:

- Financial Structure: how will the project be financed? What will be the proportion of public and private funding? It is important to choose a financial structure that allows for sustainable financing of the project over the lifetime of the partnership.
- Risk Sharing: What risks will be shared between the public and private sectors? It is essential to clearly define how risks will be identified, assessed and shared between the two parties.
- Governance and Operations: How will the transport infrastructure elements be managed and operated? What will be the management and maintenance arrangements once construction is completed? An effective governance and operational model needs to be chosen.
- Project Duration: How long will the partnership last? Some projects may be suitable for long-term partnerships, while others may be suitable for shorter-term collaborations. Project duration should be considered when selecting a PPP model.
- Support for Innovation: How does the project support innovation and modern technology? Does the project include mechanisms to support innovation and improve services for transport users?

The right choice of PPP model for transport construction can contribute to project success and ensure optimal use of resources. A thorough analysis and consultation with experts in finance, law and engineering is essential to select the most appropriate partnership model for the project.

PPP Projects and Sustainability

Sustainability plays a key role in the context of public-private partnerships (PPPs) in transport. Sustainability refers to the ability of a project to meet current needs without compromising future generations, taking into account economic, environmental and social factors. Here are ways in which PPP projects can support sustainable development:

Economic Sustainability: PPP projects can improve the efficiency of infrastructure financing, allowing efficient use of public resources and reducing pressure on government budgets. This leads to economic stability and long-term sustainability.

Environmental Sustainability: PPP projects can be designed with a view to reducing negative environmental impacts. This may include the construction of environmentally friendly transport systems, the promotion of public transport and the minimisation of emissions.

Social Sustainability: PPP projects can improve access to transport for all sections of society, including people with reduced mobility. Creating barrier-free and accessible transport systems can promote social integration and inclusion.

Innovation and Technological Progress: The private sector can bring innovative technological solutions to transport projects, which can lead to reduced energy consumption, better transport planning and improved overall infrastructure sustainability.

Long-term Maintenance and Upgrades: PPP agreements can include long-term commitments to maintain and upgrade infrastructure for the duration of the contract, ensuring that transport systems remain operational and safe in the future.

Including sustainable elements in PPP projects is key to creating viable and responsible transport infrastructure. This not only benefits current residents, but also protects the environment and promotes sustainable development for future generations.

Challenges and Constraints in PPP Projects in Transport

Although PPP projects bring many benefits, they also face various challenges and constraints that can affect their success. Some of these challenges include:

- Financial Risks: the biggest challenge for PPP projects is often associated with financial risks. Interest rate fluctuations and currency fluctuations can affect project costs and cause financial instability.
- Political Changes: Political changes in a country can have a significant impact on PPP projects, especially if there is a change in political attitude towards private investment or regulation.
- Risk Management: Identifying, assessing and managing risks are key to the success of PPP projects. Inadequate risk management can lead to financial losses and project delays.
- Project duration: The long-term nature of PPP projects can be a challenge as it implies long-term commitment and stability on the part of both the public and private sectors.
- Transparency and Integrity: Lack of transparency and absence of integrity processes can lead to corruption and unfair practices in the procurement process.
- Accountability for Services: The public sector is responsible for delivering services to citizens. Inadequate quality or availability of services can lead to citizen dissatisfaction and political uncertainty.

The solution to these challenges is careful project preparation and analysis, transparency in processes, good risk management, and effective collaboration and communication between the public and private sectors. These elements are key to achieving successful and sustainable PPP projects in the transport sector.

The Future of PPP Projects in Transport

With advances in technology, environmental changes and increasing urbanisation needs, PPP projects in transport are expected to play a key role in the future. Several trends indicate the direction this form of partnership may take:

- Smart Infrastructure: the use of technologies such as sensors, artificial intelligence and IoT (Internet of Things) in public infrastructure. This smart technology enables better traffic management, increases safety and optimises traffic.
- Sustainability: The increasing focus on sustainability is leading future PPP projects to focus more on green solutions such as electric vehicles, cycle paths and public transport support.
- Mobility as a Service (MaaS): The MaaS concept integrates different forms of transport into one system that is easy to access and use for passengers. PPP projects can play a key role in implementing MaaS in cities.
- Innovative Financing: New financing mechanisms such as green bonds and sustainable development funds can support the financing of PPP projects with an emphasis on sustainability and innovation.

- Inclusion of Communities: Involving communities and residents in planning and decision-making for transport infrastructure is increasingly important. Open dialogue with the public can lead to better acceptance and success of PPP projects.

These trends suggest that the future of PPP projects in transport will depend on flexibility, innovation and responsiveness to the changing needs of society. Adequate adaptation to new technologies and sustainable practices will be key to sustaining the success of these projects in the future.

Conclusion and discussion

In conclusion, Public-Private Partnership (PPP) projects in transport have the potential to contribute significantly to the development of modern and efficient transport infrastructure. We have stressed the importance of the right choice of PPP model, transparent risk management and public involvement in decision-making processes. Examples of successful PPP projects from different parts of the world show that this form of partnership can lead to high quality and innovative transport solutions.

With increasing challenges such as climate change, rising demand for mobility and the need for sustainability, future PPP projects will need to be flexible, sustainable and focused on the needs of citizens. Incorporating smart technologies, promoting sustainable mobility and involving communities in the planning process will be key to the success of future PPP transport projects.

We believe that the right use of PPP transport projects can have a long-term positive impact on economic growth, the environment and the quality of life of residents. Managing these projects responsibly and maintaining a long-term view are key to achieving sustainable transport development in the 21st century.

Acknowledgement

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8. Impact of The Time Step Calculation On The Energy Performance Of Buildings

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Abstract

The European Union's climate and energy policy has set up a series of objectives, for which reducing the energy performance of buildings plays a key role. Proper energy savings evaluation is an important chapter in this effort. According to Annex V to the Energy Efficiency Directive, one of the recognized methods for the evaluation of the impact of energy saving measures as well as in the design of new buildings is the ex-ante method. The ex-ante method is based on a theoretical calculation of the energy performance of the building and the determination of its future energy consumption. In the Czech Republic, the calculation with monthly steps was almost exclusively has been used until the end of 2022, but from the beginning of 2023 the calculation with hourly steps is in place.

The aim of this work is to compare and analyze the differences that arise when calculating the energy performance of a building using monthly and hourly time steps, and to determine its impact on the possible achievement of energy consumption reduction targets and future planned energy efficiency requirements.

The calculation is performed on selected building model based on the case study of the real planned residential project of new positive energy district using calculation software. The differences between hourly and monthly steps are then analyzed.

The study results show a significant dependence of the resulting building theoretical energy balance on the climate and operational inputs used in the calculation. The hourly step has proven to be more accurate compared to the monthly step, better reflecting the flexibility of building use, but is highly dependent on the correct setting of operational input parameters and in the case of the design of new buildings, where design optimization is required, significantly increases the processing time.

Keywords

Energy performance of buildings, calculation methodology, time step, positive energy district

Introduction

The European Union's climate and energy policy has set a number of specific targets, among which increasing energy efficiency, i.e. reducing energy consumption, plays one of the key roles. Buildings play an important role in this respect as they account for 40% of the Union's total energy consumption. However, a significant part of the existing building stock, which largely consists of buildings built in the last century and of which up to 85 % of buildings are estimated to stand in 2050 **Chyba! Nenalezen zdroj odkazů.**, is still energy inefficient. Moreover, it is not only existing buildings that are of great importance, but also new buildings, whose technical and technological parameters should be set to minimize their environmental impact, including minimizing their (primary) energy consumption. In addition, the requirements for new buildings are gradually increasing.

Based on the Green Deal strategy and its implementation package Fit for 55 **Chyba! Nenalezen zdroj odkazů.**, key energy directives are being revised and targets for renewables and energy efficiency are being increased. New Energy Performance of Buildings Directive (EPBD IV) will introduce a zero-emission building energy standard, that represents a shift not only in the energy demand of the building, when the total annual consumption of primary energy should be covered from renewable energy sources (RES) on an annual or seasonal basis, but also a very significant shift in the evaluation of the building carbon footprint (i.e. GWP – global warming potential) [3].

The EU taxonomy was also introduced in 2020. It is a classification system or tool for evaluating "green" or environmentally sustainable activities, is intended to facilitate the assessment of the impact of activities on the natural environment. Sustainable activities should then be prioritized for funding by investors or financial institutions. In terms of buildings, for example, the EU Taxonomy requires that the primary energy consumption of a new building is 10% less than the national threshold for nZEB [8].

Based on the above, the period from 2026 to 2030, when the requirements according to the newly revised key European directives and other strategies will come into effect, is to become an important milestone. Therefore, energy-saving measures in existing buildings as well as appropriate parameter setting of new buildings play an important role in meeting the set targets.

The best way to verify the effectiveness of an energy saving measure or the set parameters of the buildings is to directly measure the energy consumption (either before and after or within the new consumption). However, obtaining real data is a time-consuming and technically demanding process and this approach is not suitable for new buildings. Moreover, when setting technical and technological parameters, it is necessary to know in advance what results are to be achieved so that the parameters can be optimized if necessary.

The Directive 2012/27/EU on energy efficiency (EED) [4] as amended in Annex V presents 4 methods that can be used to for the evaluation of the impact of energy saving measures. One of the recognized methods is the ex-ante method. The ex-ante method is based on the prospective calculation of the energy performance of building based on the given input parameters and represent the deemed or expected energy state. Energy savings are then calculated as the difference between the existing or reference state and the new/designed state. The calculation is often carried out within the framework of building energy performance certificates.

This approach is used across the Europe. For example, Slovakia uses it to derive energy savings values for many of its policy measures [5]. In the case of the Czech Republic, an ex-ante calculation, in the form of a building energy performance certificate (PENB) before and after the implementation of an energy measure, is required by the New Green Savings Program [6], as evidence of the level of energy savings on which the amount of subsidy for the energy saving measure in question is based.

The method and requirements for the calculation of the building energy performance are governed by the Directive 2010/31/EU on the energy performance of buildings (EPBD II) as amended and the resulting national regulations. The calculation is also supported and embedded in a series of technical standards aimed directly at the energy performance of buildings.

The calculation of the energy performance of the building is performed against specified boundary conditions, which, in addition to the technical and technological building parameters, include climatic data (outdoor

temperatures, solar irradiation, etc.) and building operating conditions. According to the standard ČSN EN ISO 13790, in the year 2008 it was already possible to calculate the energy performance of a building using either a monthly calculation step or an hourly calculation step. Greater support for the hourly step was then received in the later standards, for example currently valid standards ČSN EN ISO 52000-1 and ČSN EN ISO 52016-1.

In the Czech Republic, mainly for the purpose of energy performance certificates (PENB), the calculation with monthly steps was almost exclusively used until the end of 2022. One of the reasons was the lack of suitable or reference national hourly data. However, from the beginning of 2023 the calculation with hourly steps is in place. The transition to an hourly calculation step follows the Decree 264/2020 on the Energy Performance of Buildings [7], which incorporates the requirements of European directives. The decree modified the calculation methodology and made a requirement that "*In buildings or zones with cooling, humidity treatment or electricity generation, the calculation shall be performed with an interval of no more than one hour.*" [7] However, the one-hour step was introduced in the calculation software as a standard for all cases, at least in case of Energie software.

In the Czech Republic, two main software are used to calculate the energy performance of a building and to create a building energy performance certificate. After the transition to the hourly step, the number of input data increased (partly due to improvements in calculation methodology) and the calculation time increased many times, from a few minutes to tens of minutes and even to more than an hour. A question is to what extent the accuracy or predictive power of the calculation results has increased and what will be the potential impact on compliance with legislative requirements and on savings reported under Article 7 of the EED, which sets mandatory energy savings targets.

Goals of the study

The main goal of this work is to compare and analyze the difference that arises when calculating the energy performance of a building using monthly and hourly time steps, and to determine its impact on the possible achievement of actual as well as planned future energy consumption reduction targets. The analysis is carried out on the case study on the one of the planned projects of a new residential positive energy district in the Czech Republic.

Methodology

The calculation and analysis are performed on selected building model based on the real planned residential project. The calculation analyses the differences between hourly and monthly steps and compares the results against the actual and future planned building energy efficiency requirements.

The calculation is performed using the Energie software for the set building parameters. For climate data and operating times, the mandatory monthly values according to ČSN 73 0331-1 and hourly values based on the reference climate year as developed by the MIT are used [9]. Calculations are carried out in accordance with the applicable standards ČSN EN ISO 52000-1 and ČSN EN ISO 52016-1.

Building model is based on the layout drawings and pre-feasibility study on the positive energy district, which is assessed according to the methodology from the PED-ID project [10]. A total of 13 residential buildings are planned as part of the project, which aims to build a modern, affordable, and energy-efficient neighborhood. These are five to seven-story, flat-roofed, pavilion-type apartment buildings, where photovoltaics are planned to be installed. The project has following parameters based on the documentation from 07/2023:

- Built-up area 4 624 m^2/ total enclosure 80 434 m^3
- Total gross floor area 25 270 m^2 / energy reference area 23 961 m^2
- Planned number of apartments 329 / planned number of inhabitants 664

The new neighborhood is planned on the site of a former mine, so the assessment also considered the option of a water-to-water heat pump that would draw energy from one of the former mining shafts. In addition, the use of

a gas-fired condensing boiler, an air-to-water heat pump and the installation of air handling units were considered, all with the aim of reducing primary energy consumption as much as possible and meeting future building energy performance requirements. The following tables summarizes the initial building parameters considered in the calculation.

Table 1: Default building technical parameters (source: investor's assignment, author, Decree 264/2020)

Building construction	Heat transfer coefficient U [W/m².K]	Heat transfer coefficient U – comparison with the new building recommended requirements / passive standard [W/m².K]
Walls	0.185	0.210 / 0.180–0.120
Flat roof	0.160	0.168 / 0.150–0.100
Floor on the ground	0.250	0.315 / 0.220–0.150
Floor above unheated basement	0.250	0.315 / 0.220–0.150
Floor above outdoor environment	0.160	0.168 / 0.150–0.100
Openings (window)	0.900	1.050 / 0.800–0.600
Openings (doors)	0.900	1.190 / 0.900
Doors to apartments	1.500*	1.190 / 0.900

** Based on market research, doors with worse parameters were considered, will be further revised*

Table 2: Default building technology parameters (source: author)

Technology system	Heating efficiency	Hot water preparation ef.	Other information
Air-to-water heat pump	SCOP* 3.5	SCOP 2.6	100% heating, 85% hot water preparation
Water-to-water heat pump	SCOP 4.7	SCOP 3.2	100% heating, 85% hot water preparation
Electric boiler	-	99%	15% hot water preparation
Gas condensation boiler	98%	98%	100% heating and hot water preparation
Heating distribution system			Seasonal heat distribution and storage efficiency 89.0% Seasonal heat sharing efficiency 83.0%
Mechanical ventilation	75% heat recovery		In operation 70% of the time, energy class C system (average system)
Lighting			Light source factor 1,7 (15% bulbs, 85% conventional LED lighting)

** Seasonal heating factor (SCOP) represents efficiency – SCOP 3,5 can be considered as 350%.*

Results

The results in this chapter are presented for a technology variant with an air-to-water heat pump with heating SCOP 3.5 and hot water SCOP 2.6 with a bivalent electric boiler source (μ = 99%) and natural ventilation. First, a comparison of the energy performance of buildings in monthly and hourly calculation steps is presented. Then, the electricity consumption from a 1000 kWp photovoltaic power plant to be built on a neighboring property is analyzed in monthly and hourly balance.

The first set of tables compares the energy performance of buildings in monthly and hourly calculation steps and relates the results to the national energy class rating and the assessment of compliance with the national nearly-zero energy building (nZEB) standard requirements applicable from 2022 and the EU Taxonomy requirements for new buildings.

The results in table 3 show that none of the buildings under the monthly step will meet the legislative requirements, in the case of the hourly step only 5 buildings will meet the national requirements for the nZEB standard without any other improvements.

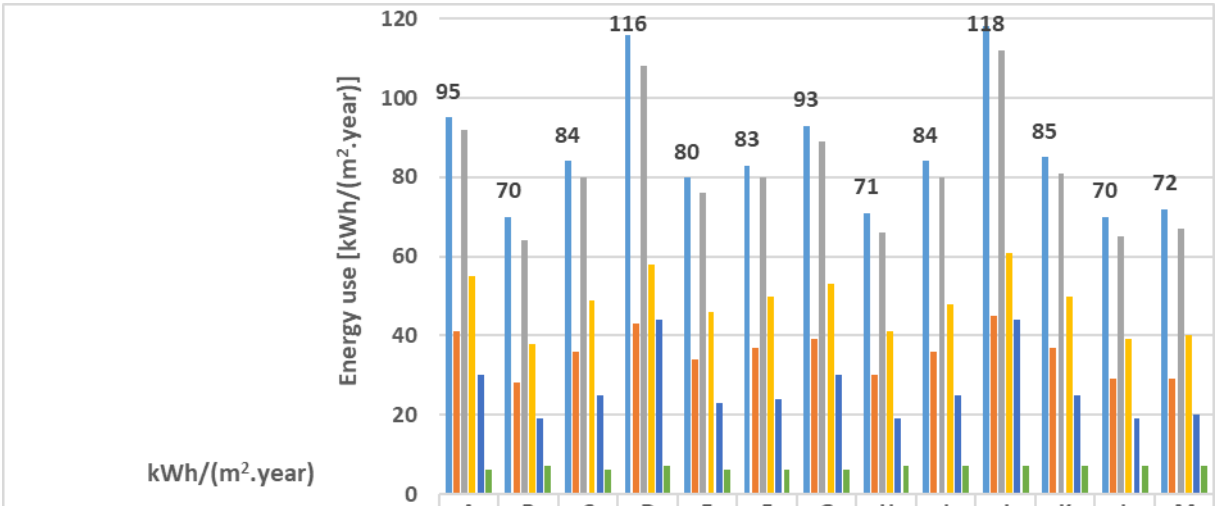
Table 3: Basic comparison of calculated building requirements (source: author)

Building #	Energy class	Non-renewable primary energy use [kWh/(m². year)]	Compliance with the nZEB requirement from 1.1.2022	Meeting the EU taxonomy requirement for new buildings	Energy class	Non-renewable primary energy use [kWh/(m². year)]	Compliance with the nZEB requirement from 1.1.2022	Meeting the EU taxonomy requirement for new buildings
	Monthly calculation step				Hourly calculation step			
A	C	95	No	No	B	85	No	No
B	B	70	No	No	B	66	Yes	No
C	B	84	No	No	B	77	Yes	No
D	C	116	No	No	B	100	No	No
E	B	80	No	No	B	78	No	No
F	B	83	No	No	B	80	No	No
G	C	93	No	No	B	84	No	No
H	B	71	No	No	B	68	Yes	No
I	B	84	No	No	B	78	No	No
J	C	118	No	No	B	101	No	No
K	B	85	No	No	B	78	No	No
L	B	70	No	No	B	67	Yes	No
M	B	72	No	No	B	70	Yes	No

For all buildings to meet the requirements of the nZEB from 1.1.2022 and the EU taxonomy (each must meet them for itself), renewable energy sources must be implemented. The easiest option is to install a photovoltaic power plant, which should have the following parameters for all buildings together, so that each building meets the above requirements (overflows to the public distribution network are excluded from the assessment, but otherwise they may further reduce primary energy):

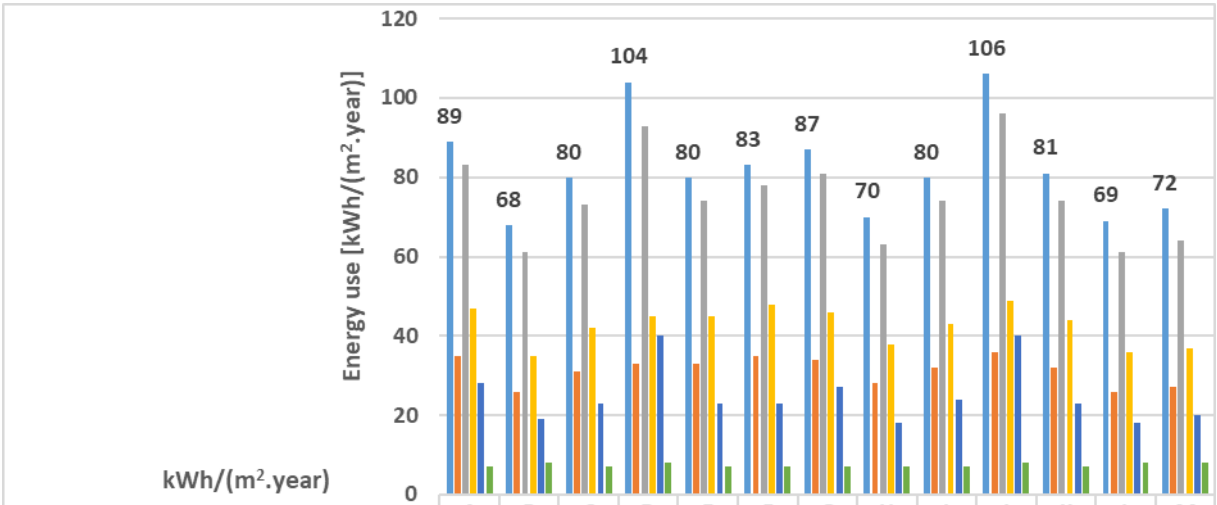
- In monthly method for nZEB: 83.5 kWp / 394.7 m^2 effective PV panel area / 189 PV panels
- In hourly method for nZEB: 51.0 kWp / 241.1 m^2 effective panel PV area / 118 PV panels
- In monthly method for EU Tax: 164.4 kWp / 681.9 m^2 effective panel PV area / 322 PV panels
- In hourly method for EU Tax: 128.9 kWp / 534.8 m^2 effective panel PV area / 253 PV panels

The following figures show a closer comparison of primary energy consumption and final energy consumption between the monthly and hourly calculation steps. The values are based on the square meter of the building energy reference area. In most cases, the hourly calculation yielded lower consumption values. This is in direct contradiction to the findings according to a study presenting climate data and typical usage parameters for an hourly calculation step [9] , where instead the hourly step in case of apartment building resulted in higher consumption values. The exception is the energy use for lighting, which is higher in hourly step, which is following the study findings.



	A	B	C	D	E	F	G	H	I	J	K	L	M
Non-renewable primary energy use	95	70	84	116	80	83	93	71	84	118	85	70	72
Specific energy need for heating	41	28	36	43	34	37	39	30	36	45	37	29	29
Total energy use	92	64	80	108	76	80	89	66	80	112	81	65	67
Energy use for heating	55	38	49	58	46	50	53	41	48	61	50	39	40
Energy use for hot water preparation	30	19	25	44	23	24	30	19	25	44	25	19	20
Energy use for lighting	6	7	6	7	6	6	6	7	7	7	7	7	7

Figure 1: Resulting parameters according to the monthly step calculation (source: author)



	A	B	C	D	E	F	G	H	I	J	K	L	M
Non-renewable primary energy use	89	68	80	104	80	83	87	70	80	106	81	69	72
Specific energy need for heating	35	26	31	33	33	35	34	28	32	36	32	26	27
Total energy use	83	61	73	93	74	78	81	63	74	96	74	61	64
Energy use for heating	47	35	42	45	45	48	46	38	43	49	44	36	37
Energy use for hot water preparation	28	19	23	40	23	23	27	18	24	40	23	18	20
Energy use for lighting	7	8	7	8	7	7	7	7	7	8	7	8	8

Figure 2: Resulting parameters according to the hourly step calculation (source: author)

Table 4: Differences in calculated parameters between monthly and hourly methods (source: author)

Building #	Non-renewable primary energy use	Specific energy need for heating	Total energy use	Energy use for heating	Energy use for hot water preparation	Energy use for lighting
A	-7%	-17%	-11%	-17%	-7%	14%
B	-3%	-8%	-5%	-9%	0%	13%
C	-5%	-16%	-10%	-17%	-9%	14%
D	-12%	-30%	-16%	-29%	-10%	13%
E	0%	-3%	-3%	-2%	0%	14%
F	0%	-6%	-3%	-4%	-4%	14%
G	-7%	-15%	-10%	-15%	-11%	14%
H	-1%	-7%	-5%	-8%	-6%	0%
I	-5%	-13%	-8%	-12%	-4%	0%
J	-11%	-25%	-17%	-24%	-10%	13%
K	-5%	-16%	-9%	-14%	-9%	0%
L	-1%	-12%	-7%	-8%	-6%	13%
M	0%	-7%	-5%	-8%	0%	13%

** Negative values mean that the results in the hourly step are lower compared to monthly step. A plus value means they are higher.*

It should be noted that although the consumption values according to the hourly step are smaller than those calculated in the monthly step, the calculation step has minimal impact on the nZEB and EU Taxonomy requirements, which remain almost the same (the difference is about 1-2 kWh/m^2.year).

The last comparison consists in evaluating the usability of electricity from photovoltaic power plants designed on the roofs of the assessed buildings (separate power plant for each building). The balance of energy consumption versus electricity production is considered in aggregate for all buildings based on the monthly and hourly energy balance. Figure 3 shows the main differences in both balances.

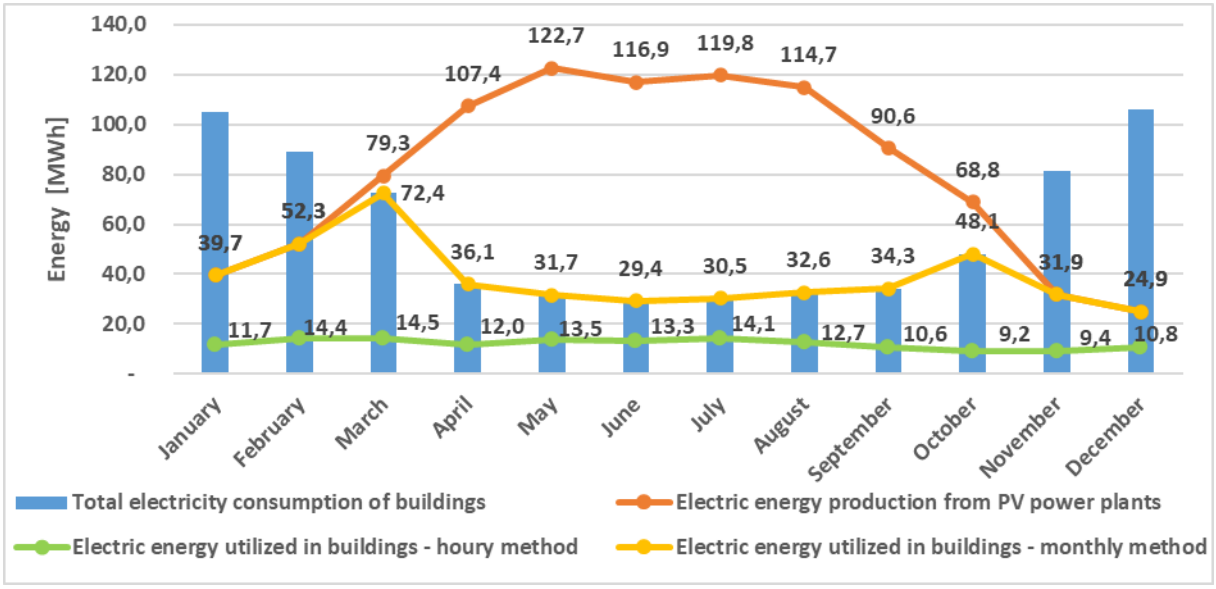


Figure 3: Comparison of PV energy use for self-consumption in monthly and hourly balance (source: author)

The table 5 shows the pairing of production with energy consumption in the monthly balance. The table 6 presents the hourly balance, which shows a significantly lower direct electric energy utilization in the buildings. This is mainly due to the imbalance between production (occurs mainly during the day) and consumption (occurs mainly in the morning and evening), which is not sufficiently reflected in the average monthly balance.

Table 5: Photovoltaic energy utilization in case of comparison on a monthly basis (source: author)

	Electric energy production from PV power plants (MWh)	Total electricity consumption of buildings (MWh)	Electric energy utilized in buildings (MWh)	Electric energy overflows into the grid (MWh)	Building consumption – electricity consumption from the grid) (MWh)
January	39.7	104.8	39.7	0.0	65.1
February	52.3	89.1	52.3	0.0	36.9
March	79.3	72.4	72.4	6.9	0.0
April	107.4	36.1	36.1	71.4	0.0
May	122.7	31.7	31.7	91.0	0.0
June	116.9	29.4	29.4	87.5	0.0
July	119.8	30.5	30.5	89.3	0.0
August	114.7	32.6	32.6	82.2	0.0
September	90.6	34.3	34.3	56.3	0.0
October	68.8	48.1	48.1	20.8	0.0
November	31.9	81.1	31.9	0.0	49.2
December	24.9	105.8	24.9	0.0	80.9
Total	**969.0**	**695.7**	**463.6**	**505.3**	**232.1**

Table 6: Photovoltaic energy utilization in hourly step energy balance in the Energy software (source: author)

	Electric energy production from PV power plants (MWh)	Total electricity consumption of buildings (MWh)	Electric energy utilized in buildings (MWh)	Electric energy overflows into the grid (MWh)	Building consumption – electricity consumption from the grid (MWh)
January	39.7	104.8	11.7	28.0	93.1
February	52.3	89.1	14.4	37.9	74.8
March	79.3	72.4	14.5	64.8	57.9
April	107.4	36.1	12.0	95.5	24.1
May	122.7	31.7	13.5	109.1	18.2
June	116.9	29.4	13.3	103.6	16.1
July	119.8	30.5	14.1	105.7	16.4
August	114.7	32.6	12.7	102.1	19.9
September	90.6	34.3	10.6	79.9	23.6
October	68.8	48.1	9.2	59.6	38.9
November	31.9	81.1	9.4	22.5	71.7
December	24.9	105.8	10.8	14.1	95.0
Total	**969.0**	**695.7**	**146.1**	**822.9**	**549.6**

The last table shows the percentage of direct use of energy from photovoltaic power plants in buildings and the level of unused energy or possible overflows into the public grid. Energy storage is not considered. In the case of the hourly method, results are presented for the Energy software and the PV SOL software, the differences are due to the distribution of consumption over the year (PV SOL distributes energy consumption according to its own usage profile).

Table 7: Comparison of photovoltaic energy use based on the energy balance time step (source: author)

Parameter	Monthly method	Hourly method (from Energie)	Hourly method (from PV SOL)
Used % of the production from the PV plant in the building:	47.8%	15.1%	23.6%
Overflow to the grid / non-used energy	52.2%	84.9%	76.4%
Buildings electricity consumption reduction by	66.6%	21.0%	32.8%
Resulting electricity needed from the grid compared to total electricity consumption	33.4%	79.0%	67.2%

Conclusion and discussion

The results of this study show a significant dependence of the resulting theoretical energy balance of the building on the climate and operational inputs used in the calculation. These are caused mainly by differences between hourly and monthly data, where the hourly data converted to monthly data is different from the used monthly data (see the standards and studies in question for more details).

The values according to the hourly step calculation came out lower than the values according to the monthly step, which is not consistent with the findings in the study on hourly data. Further modelling will therefore be required, including closer verification of the correct parameter settings in the Energie software. The aim will be to verify the computational differences more closely, especially at the level of individual systems (heating, hot water, ventilation…) and calculation details (coefficients, etc.).

The hourly step calculation has proven to be more accurate compared to the monthly step, better reflecting the flexibility of building use (i.e. possibility to adjust or plan the energy consumption in the building depending on the availability of cheap or green energy), but in case of ex-ante calculation it is highly dependent on the correct setting of operational input parameters and in the case of the design of new buildings, where design optimization is required, significantly increases the processing time. Nevertheless, especially in the case of analyzing the utilization of the energy produced by PV plants, the hourly step proves to be much more accurate as it takes into account the unevenness of energy production versus energy consumption better than a coarser monthly balance. Anyway, the results can vary quite a lot depending on the distribution of energy needs during the day (as shown in table 7), which results from the setup of the operating conditions. Standard operating conditions may not be the most appropriate and should be adapted to the intended use of the building where necessary. The topic of flexibility should therefore be further investigated in this respect.

The results themselves show that even a building designed with relatively good parameters (better than the minimum national requirements) may not meet all the legislative requirements on the building energy performance, let alone future requirements. This puts more pressure on the design of the building to a passive standard or the implementation of renewable energy sources, especially photovoltaics, that can very well improve the building energy rating.

However, the trade-off between building parameters and PV will not be sufficient from 2030 onwards, as the full coverage of new buildings' consumption by renewables will need to be addressed. Therefore, both the maximum reduction of energy consumption with best available options and its coverage by RES will be important. At the same time, the environmental footprint of materials will have to be addressed, which will put pressure on the entire

building sector, from manufacturers to designers and construction companies to energy specialists. It will therefore be necessary to further analyze the design energy related parameters of the buildings to achieve a significantly better energy balance to meet future requirements. This will also apply to existing buildings that are due to undergo energy renovation, for which the requirements are to be slightly lighter but still quite substantial.

Acknowledgement

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9. Implementing the bim method on the construction sites of the road and motorway directorate cz

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Abstract

In addition to the necessity of innovations in the construction industry, the aim of the article is to present the current state of preparation and implementation of the BIM method as a fundamental tool for digitalization of the construction industry, specifically on the construction sites of the Road and Motorway Directorate of the Czech Republic (RMD). Furthermore, the article introduces the work with BIM in practice, specifically on the currently implemented D4 motorway project between Příbram and Písek, which is the first motorway construction in the Czech Republic financed in the form of PPP (Public Private Partnership).

Keywords

innovation; BIM; CDE, motorway; D4; PPP

Introduction

While on the one hand the construction sector is one of the key industries in terms of impact on GDP, paradoxically, on the other hand, it is one of the least digitised industries. In terms of efficiency, i.e. productivity (the ratio of outputs to inputs expressed in financial resources or in units of labour), the situation in the construction sector (in aggregate) over the last 25+ years is really unflattering compared to other sectors as shown in Figure 1.

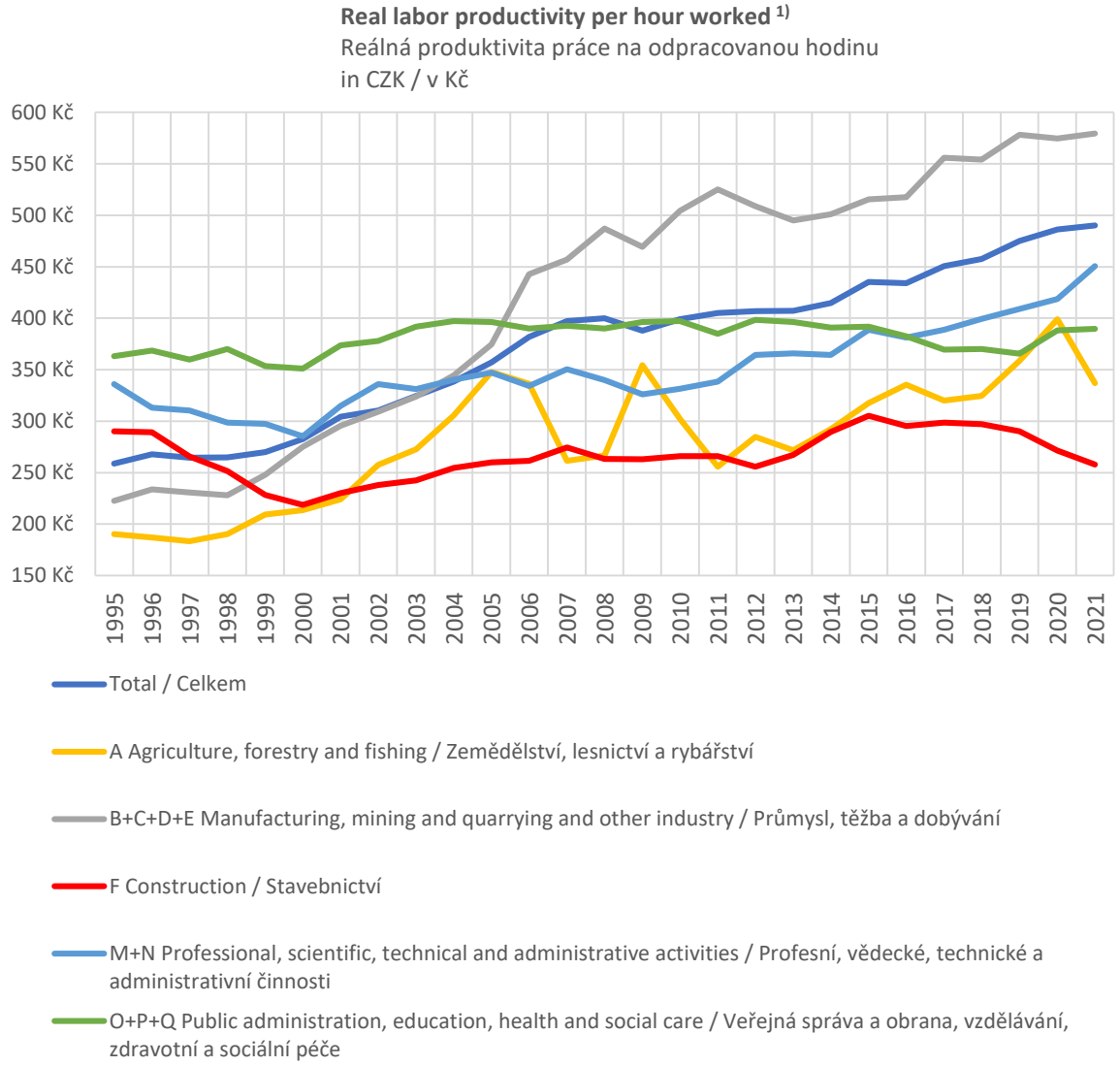

Figure 1 Real labour productivity per hour worked, selected industries [1]

Even in view of the above, the introduction of sustainable, i.e. environmentally and generation-friendly innovations in terms of new materials, construction technology, sustainable project management processes, etc. into the construction sector is absolutely necessary. Any forms of resistance, especially from representatives of political parties and/or movements represented in the Czech Parliament (it is expensive for us, we cannot afford it at this moment) or arguments such as it will increase the unemployment rate, etc. are populist and very irresponsible towards the next generations. Ultimately, the introduction of individual advanced technologies, not only in the construction sector, is decided primarily by the competitive market environment, not by the governments of individual countries (with a market economic environment). It is up to individual governments, the Czech government being no exception, to create appropriate conditions for healthy competition in business, support

promising industries, building and promoting the so-called knowledge economy on the one hand, and active and effective measures to eliminate corruption, clientelism, conflicts of interest, etc. on the other.

A fundamental and essential tool for increasing productivity (not only) in the construction sector is the introduction of digital technologies, i.e. digitalisation. One of the tools for more efficient preparation, implementation (mutual coordination, planning) and subsequent management of a project and reduction of costs throughout its lifetime is the so-called BIM model (Building Information Modelling). The history of Building Information Modelling dates back to 1975, when Professor Charles M. Eastman, then working at Georgia Tech (Georgia Institute of Technology, USA), compiled the so-called Building Description System, which later gave him a title as the *father of BIM*. [2]

In the Czech Republic, the relevant activities of the competent state administration authorities, namely the State Fund for Transport Infrastructure (SFDI), which is a legal entity under the Ministry of Transport of the Czech Republic by virtue of Act No. 104/2000 Coll., as amended, towards the implementation of BIM in the Czech environment were initiated in 2017. In that year, the SFDI prepared the so-called Plan for the Extension of the Use of Digital Methods and the Introduction of Building Information Modelling for Transport Infrastructure (Plan) on the basis of the Resolution of the Government of the Czech Republic approving the BIM Concept. Under the schedule of the Concept for the introduction of the BIM method in the Czech Republic, approved by the Government in September 2017 and updated in January 2021, the obligation to use the BIM method was with a phased effect from July 2023. However, even this deadline, which has already been postponed once, has not been met and at this moment the proposed effect of the Act on the Management of Information on Construction and Information Model of Construction and Built Environment (BIM Act) is from July 2024.

In the Programme Statement of the Government of the Czech Republic of March 2023 it is stated: „*We will introduce the Building Information Modelling and Built Environment (BIM) draft legislation to enable the use and sharing of data for the preparation, permitting and use of buildings over their lifetime (digital twins)*." [3, p. 8]. Discussions on the substantive BIM draft legislation began during 2022 and the plan itself was approved by a government resolution in May this year. Considering the current state of affairs, it can be assumed that a draft of paragraphed text will be prepared by the end of 2023.

The legal obligation to use BIM will apply to constructions whose value exceeds the limit for over-limit public procurement for construction works (currently CZK 140.4 million) and to the preparation of project documentation for such works. The following obliged persons will be obliged:

- entities managing the property of the Czech Republic - organisational units of the state and state contributory organisations, state enterprises and state organisations;
- higher territorial self-government units (regions) and their contributory organisations;
- other legal entities, if the above-mentioned obliged persons have a predominant influence in them pursuant to Section 4(1)(e) of the Public Procurement Act. [4]

BIM (Building Information Modelling)

Implementation of the BIM method and promotion of digitisation outside the Czech Republic

The development of related technical standards (CSN EN ISO) is ensured by:

- European Committee for Standardization (CEN) at European level;
- International Organization for Standardization (ISO) at international level.

Implementation of BIM and support for digitisation in the Czech Republic

In April 2019, the SFDI established the BIM Council of Transport Infrastructure Buildings as an expert platform of the private and public sector, the primary purpose and task of which is to discuss the draft methodologies and technical regulations for BIM that have been subject to the comment procedure by the Technical Editorial Team. For the record, the members of the BIM Council include, among other representatives of the business sector, the

Czech Association of Consulting Engineers (CACE) and think-tank The Czech Infrastructure Association (ARI), of which the Faculty of Civil Engineering of the CTU in Prague is a member.

One of the core sets of standards is CSN ISO 19650 - Organisation and digitisation of information on buildings and civil engineering structures including Building Information Modelling (BIM) - Information Management using Building Information Modelling Parts bullets 1 to 5:

- Concepts and principles
- Asset delivery phase
- Asset operational phase
- Information exchange
- Security-oriented approach to information management. [5]

The standards as a whole describe the individual processes - the construction project life cycle phase and the handling of data during them.

In addition to the plan itself (latest version from as of June 2023), SFDI has updated the following key documents based on projects already implemented (through the public contracting authority):

The Data Standard, which contains the requirements for the Building Information Model and the data contained therein for road constructions for various levels of project documents (latest version V5.0 dated March 2022). As part of the next update, in addition to the data standard for as-built documentation (DSPS), the requirements for the environmental impact assessment of the construction of Class II and III roads will also be added. [6]

The BIM Protocol Methodology for the FIDIC Contract Standard (latest third edition 2022) addresses the conditions for the creation, use and delivery of the Information Model of the Works; [7]

Methodology for the selection of a CDE (Common Data Environment) and the organization of Digital Document Documents - their upload, sharing, revision, download, display, etc. in the CDE; [8]

Requirements for the BIM Execution Plan monitors the fulfilment of the Client's requirements. It is a dynamic plan that evolves during the execution process.

Other basic terms:

- Construction Classification International (CCI). In cooperation with the Czech Standardization Agency (CAS), the use of a classification system based on the CCI has been made possible on pilot projects;
- Digital Building Model (DIMS) object structure of a building with individual data objects with their properties and graphical form;
- Information Building Model (IMS) is a collection of all documents - graphic and non-graphic (alphanumeric) data about the building including the DIMS;
- Open File Format – International Foundation Classes (IFC) for sharing data between stakeholders working with different software applications.

Also, very closely related to the digitization of the construction industry are:

- The digitization of the urban planning and building proceeding (DSŘÚP), as a result the public contracting authority will submit the necessary documents for the building proceeding procedure via contracting authority portal; [6]
- A Digital Technical Map (DTM), which complements, unifies and makes available often incomplete and/or inaccurate data on the course of existing utility networks, both underground and above ground. The Cadastres of Real Estate (KN) are obliged to make these DTMs available from July 01, 2023. [6]

BIM Project – D4 motorway between Příbram and Písek using PPP model

It is currently one of the most significant infrastructure project that utilize the innovative Public-Private Partnership (PPP) model. This is the first PPP project in Czech Republic.

The general contractor DIVia stavební is a part of the VINCI Construction group, which is responsible for the construction phase of the D4 motorway. As a general contractor, it must ensure that the project is delivered on time, within budget and to the desired quality. The company uses BIM method as one of the key methods which can help to achieve these goals.

This project is divided into 9 sections, 5 of which are brand new constructions (34 km), and 4 sections (17 km) are a reconstruction of the current highway. Each such section has hundreds of construction objects based on the type of construction, including bridges, bypasses, the main route, and information systems.

The basic requirements for BIM on the project are described in one of annex of the Concession agreement. This annex serves as a guideline for the proposed BIM solution for the General Contractor. It is divided into three main sections:

- General requirements for BIM – describe the aim of the contract owner, their basic principles and defines some of the functionalities, for example: the BIM team responsibility, detail of LOD for BIM models, minimal metadata, file formats, etc;
- Requirements for the CDE – define the minimal requirements for the CDE as a *single source of truth* of the project, states the minimal functional requirements and security of the system;
- Pre-contract BEP – define the minimal requirements for LOD, LOG and LOI during and after the construction phase.

The BIM team of general contractor has created a new concept of the BIM solution, which consists of:

- Post contract BEP – an extended guideline for the annex mentioned above which specifically describes how the BIM team will implement their vision. The document currently has approximately 50 pages, with 7 annexes, which include schedules, approval processes, access matrix, Data Standard for both construction and as built models and also the sample of LOD.
- Common Data Environment (CDE) – A successful delivery of such project size requires effective collaboration of all involved parties and the right tool for that is a CDE. Based upon the Concession agreement all documents, including all approval processes, must be in CDE during the whole project duration. This requirement has led to many new opportunities for implementation, further digitization, and feedback from real-life construction sites with nearly 1,000 construction objects within the project. CDE chosen for this project is TP CDE and it currently contains 16 different document types (modules), each collecting and managing a vital part of construction documentation from electronic diaries to design drawings, quality management, health & safety management, environmental, BIM models, and others. As a single source of truth, it provides vital and always accurate information to all project members, 24/7/365 during construction phase. After the construction phase the existing modules of CDE will be partially transformed to an online project archive, while new document types (modules) will be developed solely for the purpose of serving the operator effectively in the operation and maintenance phase of the project. TP CDE has been chosen as a powerful platform which can handle multiple types of requirements and processes. System configuration has been done mostly internally by the BIM team, so it can suit the best needs of the project and can swiftly react to the requirements of the project participants. To illustrate the size of the system, here are some figures: 149,000 unique documents, each document has an average of 3 version, making it 450,000+ overall documents in the system. 483 registered users, 420 GB of unique data, 1.3 TB of overall system size as shown in Figure 2.

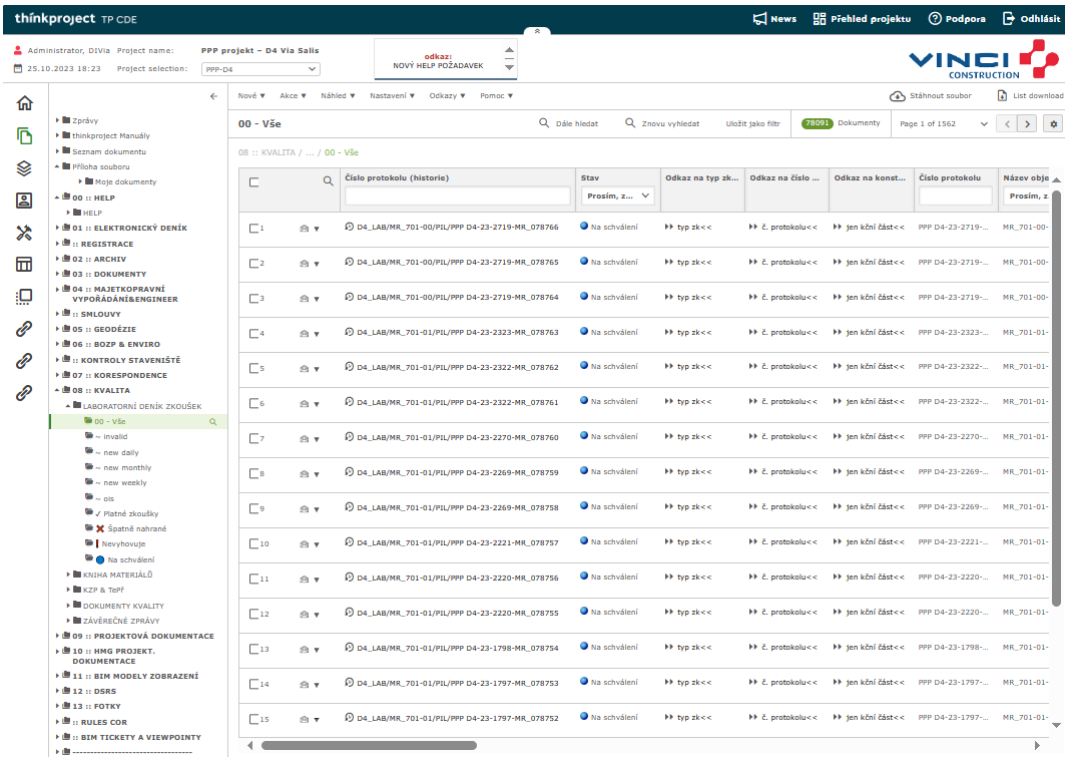

Figure 2: Common Date Environment TP CDE [9]

- LOD 100 and 300 BIM models for different construction phases
  - In the construction phase parties use LOD100 models of the highway to ease the work on and off site. The main usage is for checking future collision, visualizing design, using the model information set to check for construction object parameters, such as location, schedule, work simulation etc. as shown in Figure 3.

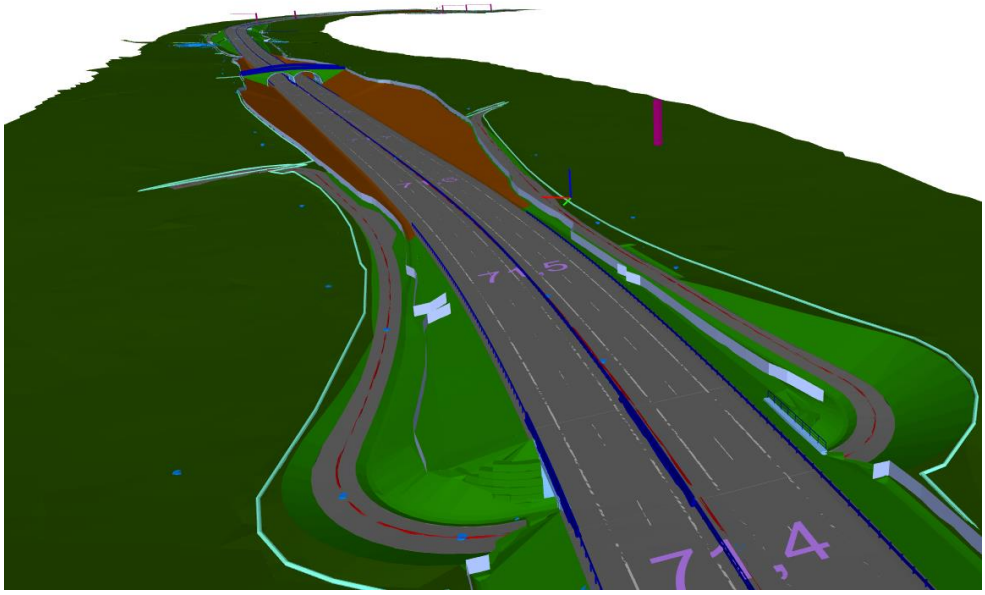

Figure 3: LOD 100 [9]

The BIM team created a custom Data Standard (DS) for both construction and operation phase because of following reasons:

- Due to the lack of approved DS at the time of the beginning of construction;

- The construction phase requires only the important project data, chosen by the need of the project without overwhelming the user;
- Due to the lack of approved DS for the as-built model;
- The ability to create a very specific operation-oriented DS, which will help the operator to maintain the highway using BIM model in the most efficient way.

The BIM team also came up with detailed design and description of LOG 300 concept – Level of Graphics 300, as the graphical requirements has not been standardized in the world of linear construction and there is very little example which could be used. The LOG 300 respects the requirements stated by the operation and maintenance.

LOD 300 as-built models will help the Concessionaire to track an asset history, cost analysis, schedule maintenance activities, track warranty information and to help overall efficient highway management.

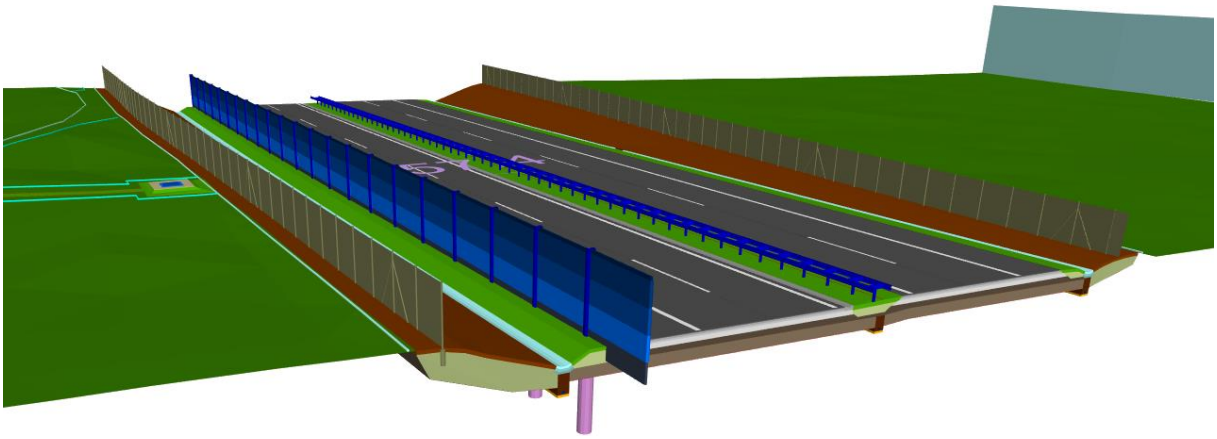

Figure 4: LOD 300 [9]

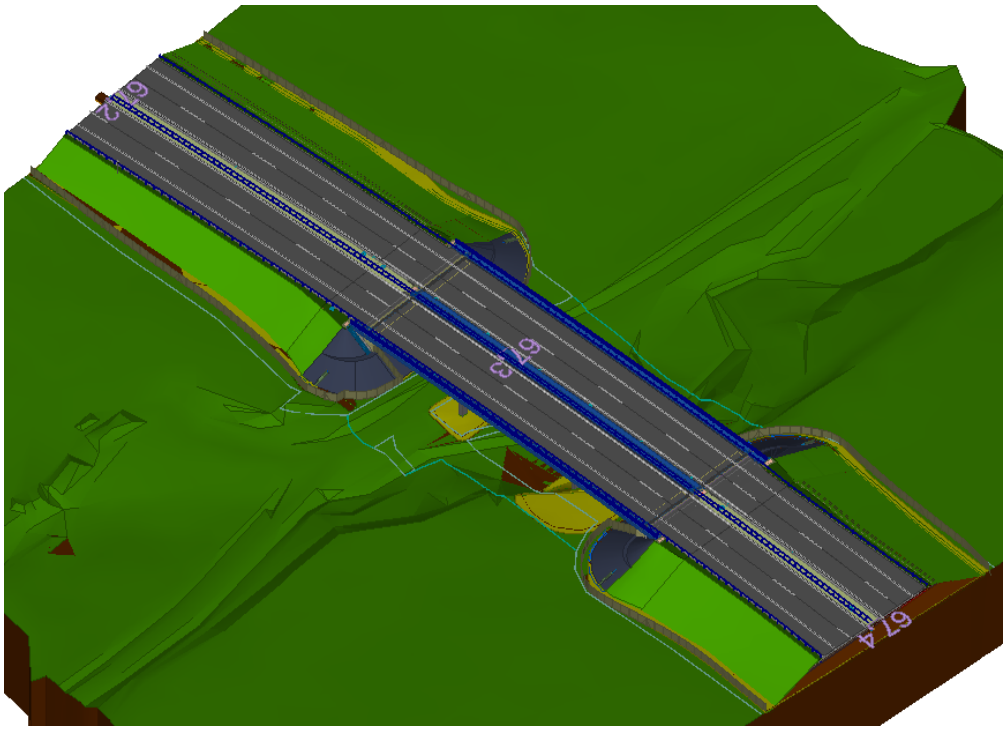

Figure 5: LOD 300 [9]

Conclusion

The purpose of introducing the BIM method, i.e. a fully functional and interconnected Common data environment (CDE), Digital building model (DIMS) and BIM Execution Plan (BEP) is not only to increase efficiency in the individual phases of project preparation and/or implementation by sharing data in one place (CDE), i.e. immediate and constant availability of relevant and up-to-date files to public contracting authorities, members of the design team, contractors, technical supervisors and others; but also in increasing the efficiency of discussing, commenting and approving individual changes to the project documentation, administration of the so-called Variations (ZBV), etc. Processing and refinement of digital models is an important tool not only for ensuring, continuous monitoring and timely elimination of possible collisions of individual parts of the work without the necessity of demolition and thus increasing the cost on the part of the contractor/contracting authority, their use leads to optimization of the process of construction work, both from the technical and time perspective, i.e. ultimately financial. High-quality models are also important for the efficiency of the subsequent management and maintenance of the work throughout its lifecycle, which is an essential attribute for the subsequent owner/operator, especially for a motorway or motorway tunnel with a life expectancy of up to 100 years.

The full implementation of the BIM method in practice requires the mastery of a complex strategic preparation by the public administration (The Ministry of Transport CZ, The Ministry of Regional Development CZ, The Road and Motorway Directorate of the Czech Republic, The State Fund for Transport Infrastructure, etc.), as well as a detailed acquaintance with the requirements of related laws, standards and regulations on the part of the contracting authorities (The Road and Motorway Directorate of the Czech Republic, local self-government units and their contributory organisations, etc.) and the bidders for these public contracts (individual construction companies, designers, etc.).

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10. University - Industry Collaboration Review: the State of Cooperation in the Aviation Industry

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Abstract

The purpose of this work is to identify cases of collaboration between higher education institutes (HEI) and players in the aviation industry in Europe to shed more light onto the industry practice of the University-Industry Collaboration (UIC) model. The following work specifies the state of the aviation industry utilizing UIC formats for research and development (R&D) and education within Europe. The biggest European players in the aviation industry have been identified based on statistical sources and own research. Players with a high degree of research and innovation needs include aircraft and component manufacturers (ACM), as well as passenger and cargo airlines. A detailed online search has been carried out selecting evidence of academic cooperation in R&D and education. Categories, such as number of academic partners, length of cooperation, and regional spread has been documented. The sensitive and technology intensive industry largely utilizes the framework of UICs for their strategic and competitive advantage. 85% of the analyzed players use at least one type of collaboration format. While some follow a rather loose and project-based form of collaboration, findings prove that a significant ratio has developed sophisticated and investment intensive strategies of collaboration. For instance, 44% of analysed ACMs created separate research and development centres with institutions. The intensity of cooperation of some global players, however, still offer room for improvement. This work serves as an insight into an industry which has realized the value of UICs and relies on the innovative ecosystem it has created thereof. Sharing of resources and transferring knowledge is a widely spread practice, making these insights serve as a basis for other industries or companies. A review of UIC on an industry level has been lacking in literature and may serve as a basis for evaluating further industries and their benefit of partnerships in form of UICs.

Keywords

aviation industry; innovation ecosystem; university-industry collaboration (UIC)

Introduction

University-Industry Collaboration in Europe

A continuous global trend sees increasing collaboration between higher education institutions (HEI) and the industry. Triggered through initiatives by the European Commission (EC), tools in form of financial nature, knowledge generation and policy making are available Europe-wide to encourage University-Industry Collaboration (UIC) on a European, national or regional level. The EC's aim is to strengthen the regions' competitive position globally [1, 2, 3] by prompting innovation efficiency and amplifying an ecosystem of continuous economic growth. Europe's largest study on UIC provides evidence that the level of cooperation is yet low and the efforts towards an understanding of academic and industry collaboration has to continue in order to bear the fruits of governmental investments [4]. Little evidence is available how this is reflected within different industry sectors and whether some sectors cooperate more effectively than others. UIC distinguishes between four types of cooperation: research, education, valorization and management, which can occur in combination of each other [4]. Research in form of collaborative or joint R&D, contracted research, consulting and the mobility of staff is the most common type of cooperation being realized in Europe, followed by education [4]. It has been identified that research and development (R&D) involves the most resources both for businesses and HEIs and is therefore a preferred collaboration model allowing sharing of resources and know-how.

Aviation value chain

In order to understand the need for UIC in the aviation industry, a closer look at its value chain is needed. Consisting of four pillars, namely aircraft and component manufacturers (ACM), airlines, airports and general service providers [5, 6], the nature of this value chain is defined by high specialization in terms of technology and safety, as well as the need of following strict regulations. High specialization and a technology intensive sector in turn assumes an investment intensive industry. While the four pillars have high financial barriers in common, their competitive dynamics behave very differently. Whilst the airline market is highly competitive, consisting of numerous regional and global players generating slim margins, the aircraft manufacturing industry includes very few players [5] and wider margins. Wide-body aircraft manufacturers for instance, fall under a duopoly [5] whilst airport operators accommodating wide-body aircrafts can be considered a monopoly in a majority of regions. A strong dependency among the pillars within the aviation value chain is evident in an environment with high barriers of entry. The forms of aviation, which are served under the four pillars can be categorized as civil (passenger and cargo), military and general aviation.

Aerospace market

As technology of aviation and space flight are strongly interrelated, the branch is frequently summarized under the term aerospace. The largest aerospace markets according to Statista's European aerospace industry report [7] are split between North America (1), Asia (2) and Europe (3). France and Germany are ranked 2nd and 3rd after the USA in terms of exports. The civil aviation market has in recent years been greatly affected by the COVID-19 pandemic and a dramatic drop in passenger numbers [8] has created a large uncertainty along the aviation value chain. The recent half-year IATA industry outlook "Global Outlook for Air Transport" documents the sharp decrease in revenue passenger-kilometers (RPK) (ca. 60 % in 2020) [9]. Airplane orders decreased from 2019-2020 by over 40% [8]. While these figures are positively rebounding, the Russian war on Ukraine is affecting the aerospace industry in a way that spending on military aviation in Europe, in particular, is increasing. The EU has committed itself to spending 500 Bn EUR over two years with the goal to establish a European Defence Investment Programme [10], which will further drive Research & Innovation (R&I) and manufacturing of the military aviation sector. Modernization, as well as ramping up equipment are of priority.

Motivation for R&I in aviation

In line with the European Green Deal's goal of becoming the first carbon neutral region in the world by 2050, the EC is looking to accelerate R&I across diverse industries. As one of the biggest polluters, yet a significantly

important industry, aviation is one such target industry. For instance, Ryan Air, Europe's largest airline in passenger numbers, was listed as the 10th biggest polluters in Europe in 2018 [11]. According to the EC, "long development cycles and high technological risks…" in the aviation industry, "…cooperation between all key private and public organizations is essential to strengthen and streamline research"[12]. "Europe's Vision for Aviation" includes strategic innovation in this field and states: "Strong, coherent research networks and partnerships between private and public actors drive European innovation and are enabled by strong public funding and a range of globally recognized, efficient instruments." [13]. Their initiative "Clean Aviation" connects Industry members, universities, research centers and SMEs [14]. The EC's fact sheet on "Research and Innovation for Aviation" emphasizes six areas of R&I, namely „reducing aircraft noise, greenhouse gas emissions and fuel consumption, thus improving safety, local air quality and minimizing our dependency on imported fossil fuels" [15], which are supported under the Horizon Europe and the Clean Aviation funding programs. A large emphasis is placed in Europe on tackling world issues through expediting R&I and through rewarding cooperation in form of funding support. As laid out, the focus on fostering UIC is deeply embedded in the EC's initiatives in form of funding and policy support. In the following study we are looking to define the state of UIC in the European aviation market and find out what trends in this field are taking place among Europe's biggest players in the aviation industry. The aim of this review is to find evidence that the aviation sector is already widely benefitting from UICs.

The research question, the study is looking to answer is whether the aviation sector is provides evidence of UIC both in research and education. The hypothesis raised is that the investment and research-intensive sector does benefit from a collaboration with universities by a significant extend in Europe. The following research is intended to derive with a general overview of the pattern of cooperation.

Literature review

The state of UIC in Europe

The state of UIC in Europe was in-depth researched in the EC commissioned report "The State of University-Business Cooperation in Europe" in 2018 [4]. The report finds that the awareness of UIC, especially within the industry is relatively low, and a number of barriers for cooperation continue to exist. The potential in generating innovation in form of UIC is largely untapped despite the efforts of the EC and its member states promoting and incentivizing this type of collaboration. According to this study, "UBC needs to be understood as an encompassing, overarching and interconnected ecosystem instead, which comprises individuals, organizations and regions" [4]. Promising results, however, are seen in the feedback of those already in collaboration. 98% of academic and 99% of business collaborators already in partnerships estimate that they plan to maintain or extent their collaboration [4]. However, barriers continue to exist, the main ones being the lack of financing and resources, bureaucracy and lack of man-power capacities, as well as (organizational) cultural differences [4]. Since the research for this European UIC study took place in 2016 – 2017, it is unclear to what level this situation has advanced till today. A follow-up study has not yet taken place; hence it is of interest to see how the involvement in UIC in Europe has changed since.

The OECD report "University-Industry Collaboration – New Evidence and Policy Options" further analyzed the state of UIC by looking at what type of policies can be recommended to drive the cooperation between science and industry [16]. Results, as put forward in their report, include an overview of a policy mix for knowledge transfer consisting of financial (some form of economic transfer from the state to firms, universities), regulatory (incentives for the participating parties incl. law-making, funding and ownership of research results) and soft factors (facilitation, relationships, networking, mobilizing, etc.) [16]. Their recommendation includes no one-size fits all, support co-creation leveraging digital technologies, improve the effectiveness of knowledge transfer and allow for diversified knowledge transfer practices. Published in 2019 and relying on data from a period between 1992-2014 from 35 OECD countries (plus China) may be considered a limitation as it does not provide current data on UIC in Europe.

Trends in higher education towards UIC

There is an evident trend of change in the HEIs' point of view towards the improvement of quality of education and research. With the aim of the initiative European Universities, the EC is promoting the formation of transnational alliances between universities in order to foster European values and at the same time enhance the quality of European higher education through collaboration. Launched in 2018, already 41 university alliances representing over 280 HEIs are being counted to date, allowing for flexibility and mobility of students in education and research. Germany is providing another successful European example of raising the level of HEIs by having introduced the long-term Excellence Initiative in form of a competition among German universities. The ongoing competition's "aim is to promote scientific excellence, develop profiles and strengthen cooperation within the science system" [17]. This motivates universities to prepare a transition from old and rigid organizational structures towards more entrepreneurial and lean ones, improving research abilities and leading German higher education to the top of the European standard. Through participation in the competition, universities are steered to evaluate their current organizational structures and develop strategies, taking a more entrepreneurial view on education and research, including industry collaboration. Results, as seen in the improved university ranking positions are evident. Following the European trend of improving the quality of HEIs, including the quality of research and education, but also moving toward a mindset of fulfilling the institutions' so-called Third Mission, more attractive collaboration possibilities within the industry sector are expected.

UICs in aviation

While the UIC model in Europe is still not so widely used in a number of industries [4], the aerospace sector in the US and Europe are benefitting from it in combination with their regional funding schemes. Aviation is known to be a complex subject and requires a number of specialized skills in engineering, operation and management. Boeing, for instance, is known to cooperate with a number of universities in their home country. Since 1990, Boeing anticipates creating stronger ties with universities to follow their organizational mission [18]. At their location in St Louis, Missouri, they established, together with the Washington University and the St. Louis Community College, a joint Engineering Leadership Development Program at affordable tuition rates. Boeing's motivation is to build a so-called "sustainable regional talent ecosystem" in order to continue having a supply of skilled engineers entering the regions workforce. "High-impact practices" are designed for the program allowing students to not only learn theory but be prepared for practical work [19]. This allows Boeing to source talent from an above average pool of skilled engineers and it allows the inhabitants to benefit from an above average supply of jobs within their field of work. About 75 % of educated engineers stay in the region.

Airbus has developed a Global University Partner Programme in order to prepare talent world-wide for satisfying the need of their industry [20]. In their paper "Engineer of the Future", the company clearly defines the engineering skills required for employability in their company and how universities can align their educational programs to suit market needs.

While these above examples focus primarily on the cooperation in education, cooperation in R&D between players in the aviation sector and universities have also been ongoing. Rolls Royce has to date established over 31 Research and University Technology Centers (UTC) globally [21]. The American aerospace manufacturer Pratt & Whitney presents a further example undertaking R&D in a UIC format. In 2019 they expanded their Center of Excellence at Ohio State University in the area of gas turbine research [22]. In 2013, GE Aviation announced the strategic collaboration with the University of Cincinnati Research Institute (UCRI), jointly creating the GE Aviation Research Center at GE's headquarters in Evendale, Ohio, where applicable innovations for GE Aviation are planned to be developed [23].

It is evident that one successful research collaboration tends to lead to the continuation of the collaboration through extending or initiating new research projects. Industry players are seeing the collaboration with universities as long-term partnerships primarily in their home market, but also internationally. While the above examples are comprising largely a North American perspective, a significant number of cooperation is taking place in Europe, incl.

those of high impact. Undoubtedly, North America is a strong leader when it comes to UIC in aviation and aerospace, however more and more activities are being initiated also in Europe.

Methodology

In this study, selected players in the aviation market have been analyzed in order to contribute to the understanding of the state of UIC in the European aviation market. The aim was to find out to what degree cooperation is taking place and what type of partnerships are favored. We are looking to find trends seen among Europe's biggest players.

As a first step, we have selected specific segments in the aviation industry to be analyzed. The two segments, ACMs, as well as passenger and cargo airlines in Europe were chosen to suite the goals of this study. These segments are highly exposed to the need for R&I under the European legislatives and visions towards sustainability. ACMs on one side, tend to follow long and investment intensive development cycles, with the resulting technologies, such as engines, being in use for several years and decades. Airlines, on the other side and due to the nature of their low margin business, are in need of optimizing operations and processes, as well as educating and training staff.

Based on various statistical data from sources and industry reports, a selection of companies with operations in Europe has been reached. A total of 40 companies, incl. 18 ACMs, as well as 22 airlines (both passenger and cargo) with global or regional headquarters (HQ) in the European Union (EU), Switzerland (CH), Norway (NO) and the United Kingdom (UK) have been chosen for the evaluation. Following, a detailed review of the organizations' websites, press releases, other online media, as well as scientific sources, information about joint academia partnerships has been collected.

The collection of data included the categorization of collaboration into two UIC areas, namely research and education collaboration according to the definition stated in "The State of University-Business Cooperation in Europe" [4] (see Table 1). The two categories, valorization and management, have not been considered within this review, as there was a lack of evidence and no clear conclusions about their state of cooperation in these areas could be outlined.

Table 1 - UBC Areas and Education and Research Activities (source Davey. T., et al.)

UBC AREAS	UBC ACTIVITIES
Education	1. curriculum co-design (e.g. employers involved in curricula design with HEIs)
	2. curriculum co-delivery (e.g. guest lectures)
	3. mobility of students (e.g. student internships/placements)
	4. dual education programs (e.g. part academic, part practical)
	5. lifelong learning for people from business (e.g. executive education, industry training and professional courses)
Research	6. joint R&D (incl. joint funded research)
	7. consulting to business (e.g. contract research)
	8. mobility of staff (i.e. temporary mobility of academics to business and of business people to HEIs)

The analysis of results as seen in Tables 2 & 3 has been carried out under the following criteria:

- Number of academic partners within the EU, CH, NO and UK
- Length of research cooperation
- Length of educational cooperation
- Regional spread of cooperation within the EU, CH, NO and UK

The number of academic partners within the EU, CH, NO and UK have been assigned to three categories, that consists of 1, 2-5 and more than 6 academic partners. The length of research and educational cooperation was analyzed according to short-term (up to two years) and long-term (more than two years) collaboration. The study further identified whether a collaboration resulted in the establishment of joint unique research centers or educational premises, which were considered the highest level of UIC cooperation within this study. If a company, for instance, was holding long-term partnerships in research with more than one partner, it was viewed as one collaboration. When a company showed evidence of a joint institution, as well as other short or long-term partnerships in research, the short or long-term partnerships, as well as the joint institution were viewed as separate activities. A regional spread of cooperation within the EU, CH, NO and UK was categorized as whether the companies cooperated with an institutional partner only in their home city, their home country or cross-border within the geographical region of the EU, CH, NO and UK. Cooperation outside this geographical definition were not taken into account. The intensity of research has not been specifically examined, yet evidence has been documented among those firms which hold a sophisticated framework for cooperation.

Results

Results of this review have been divided into the categories airlines and ACMs, and a summary of the two categories has been prepared. Companies have been listed in alphabetical order and results summarized and illustrated in Tables 2-3**.**

In an overall review based on the evidence gathered, the level of UIC in the aerospace industry can be considered high. A total of 82,5% of the analyzed companies shows at a minimum a short-term cooperation with one local partner. All eighteen ACMs showed evidence of some kind of cooperation, whereas out of the twenty-two considered airlines, seven (32%) have shown no evidence of cooperation with any academic partner. The main type of collaboration is taking place in the area of research.

Both, the segment of ACMs and that of airlines hold an almost equal split in the cooperation areas. Research achieved a 65% contribution (26 companies out of 40 where active in research), whereas education achieved 62,5% (25 companies out of 40 where active in education). Companies prefer cooperating in their home country. Of those 33 cooperating companies, 21 (64%) were engaged with an academic partner solely in their home country. 12 companies (36%) have been involved in a partnership also internationally within the boundaries of the EU, CH, NO and UK.

Table 2 – Airlines and academic cooperation (source: own research)

		Type of cooperation											
		Academic partners			Research projects			Long-term educational cooperation			Regional cooperation		
Number	Airlines	1	2-5	6+	Short to mid-term	Long-term	Joint RC	Short to mid-term	Long-term	Joint EP	City-wide	Country-wide	Europe-wide
1	Air France KLM /Air France KLM Martinair Cargo		X		X	X			X			X	
2	ASL Aviation (Cargo)												
3	Austrian Airlines	X								X			X
4	Brussels Airline												
5	British Airways		X		X			X				X	
6	Cargolux (Cargo)		X		X								X
7	Czech Airlines	X							X		X		
8	DHL Aviation (Cargo)		X		X					X		X	
9	EasyJet		X		X				X			X	
10	FedEx Express (Cargo)												
11	Iberia			X	X	X			X				X
12	ITA Airways												
13	LOT		X		X				X			X	
14	Lufthansa Group			X	X	X			X				X
15	Ryanair	X					X				X		
16	Scandinavian Airlines												
17	Swiss		X						X			X	
18	TAP Air Portugal												
19	TUIAirlines	X							X		X		
20	UPS (airlines)	X				X					X		
21	West Atlantic (Cargo)												
22	Wizz Air	X							X		X		
Total	**22**	**6**	**7**	**2**	**8**	**4**	**1**	**1**	**9**	**2**	**5**	**6**	**4**
% or Total		**27%**	**32%**	**9%**	**36%**	**18%**	**5%**	**5%**	**41%**	**9%**	**23%**	**27%**	**18%**

Table 3 – ACMs and academic cooperation (source: own research)

		Type of cooperation											
		Academic partners			Research projects			Long-term educational cooperation			Regional cooperation		
Number	ACM	1	2-5	6+	Short to mid-term	Long-term	Joint RC	Short to mid-term	Long-term	Joint EP	City-wide	Country-wide	Europe-wide
1	Airbus SE			X		X	X		X	X			X
2	Babcock International Group		X			X			X			X	
3	BAE Systems PLC			X		X			X			X	
4	Boeing			X		X	X			X			X
5	GE Aviation Europe			X		X	X		X				X
6	Embraer	X					X				X		
7	Dassault Aviation SA	X				X			X		X		
8	Leonardo SpA			X		X	X	X				X	
9	Liebherr Aerospace	X									X		
10	Meggitt PLC		X			X			X			X	
11	MTU Aero Engines AG		X			X	X					X	
12	OHB System AG			X		X							X
13	Rheinmetall Aviation			X			X			X			X
14	Rolls-Royce Holdings PLC			X			X		X				X
15	RUAG Aviation	X							X			X	
16	Saab AB		X			X			X				X
17	Safran SA			X		X			X	X		X	
18	Thales SA			X		X			X				X
Total	**18**	**4**	**4**	**10**	**0**	**13**	**8**	**1**	**11**	**4**	**3**	**7**	**8**
% or Total		**22%**	**22%**	**56%**	**0%**	**72%**	**44%**	**6%**	**61%**	**22%**	**17%**	**39%**	**44%**

Table 4 – Summary of airlines and ACMs academic cooperation (source: own research)

		Type of cooperation											
		Academic partners			Research projects			Long-term educational cooperation			Regional cooperation		
		1	2-5	6+	Short to mid-term	Long-term	Joint RC	Short to mid-term	Long-term	Joint EP	City-wide	Country-wide	Europe-wide
Sum of Airlines & ACM	**40**	**10**	**11**	**12**	**8**	**17**	**9**	**2**	**20**	**6**	**8**	**13**	**12**
% or Sum		**25%**	**28%**	**30%**	**20%**	**43%**	**23%**	**5%**	**50%**	**15%**	**20%**	**33%**	**30%**

RC – Research Centre
EP – Educational Program

As summarized in Table 2, we see that airlines prefer cooperating among 1-5 academic partners (59%), whereas 9% have partnerships with 6 or more institutions and 32% show no cooperation at all. The data further shows evidence, that airlines tend to focus more on long-term educational partnerships (41% - 9 of 22 airlines) and short-term research projects (36% - 8 of 22 airlines). Less focus is placed on the set-up and operation of joint research and educational institutions (education: 5%, and research: 8%). 73 % of the cooperating airlines favor a collaboration within the country of their home base.

In Table 3, we find evidence, that 100% of ACMs are in some sort of cooperation. ACMs place a focus on long-term research (72%), as well as on the participation in jointly established research institutions (44%). Only two of the analyzed companies did not show evidence of a cooperation in the area of research. As for educational collaboration, a strong interest in long-term educational partnerships is evident (61%). The majority collaborated with six or more academic partners (56%). Compared to the airlines (18%), ACMs are more receptive to international cooperation (44%).

Special research or educational centers

It is evident that under the UIC framework, more companies are involved in dedicated center partnerships in the area of research (9) than in the area of education (6). The benefits of such centers include, for instance, a higher organizational autonomy when dealing with a diversity of partners, as well as greater focus on the topic of research or education. Also access to funding schemes play an important role, as individual companies or institutions are less likely to obtain public funding as individual entities but have a higher change when applying in partnership. Joint research or educational centers can further bring prestige to the partners involved.

Dual education systems

Evidence of cooperation in higher dual education can be found primarily in German speaking countries, in particularly among larger corporations, such as DHL Aviation, TUI Airways, Austrian Airways and SWISS, as well as Airbus Germany, Rheinmetall Aviation and Thales. Lufthansa is well-known to cooperate with local universities with the aim to develop and train skills for future employees. For instance, Lufthansa Consulting and the International

University of Applied Sciences Bad Honnef (IUBH), are cooperating in the areas of education and internship placement, building an ecosystem for aviation management talent [24]. Moreover, Lufthansa offers, together with the Hamburg University of Applied Sciences (HAW Hamburg) a number of technical specializations for dual studies, such as repair technology, engines and electronics.

Global cooperation networks

Highly sophisticated research cooperation has been established by Rolls Royce, for instance in the form of unique University Technology Centers (UTC). Of the twenty-four UTCs, eighteen are situated in Europe, specifically in the UK, Germany and Italy and tackle very specific research topics for engine technology [21]. One such center, for instance, was inaugurated in 2006 by Rolls-Royce and the Technical University Dresden for 'Lightweight Structures and Materials and Robust Design' and continues being a vital part of the university asset.

Regional focus

While the majority of players and their cooperation partners are located in the UK, France and Germany, an evidence of cooperation is also taking place in Spain, Italy and the Netherlands. Much less known cooperation is currently taking place in Central and Eastern Europe. One prominent case in this region is the cooperation between GE Czech Republic and the Czech Technical University in Prague (CTU), who signed a strategic collaborative agreement in an attempt to innovate the market of turboprop engines and provide an ecosystem for aerospace technologies in the Czech Republic. As agreed under a joint research collaboration agreement, GE Aviation is providing the know-how of aircraft engine modeling and testing, CTU is contributing its infrastructure, knowledge, innovation potential and students. The highly complex and financially intensive cooperation involves also the presence of government support both in mediating the agreement, as well as in financially assisting the academic side it. In 2021, the organizations further announced a formal collaboration in the R&D of sustainable aviation fuel (SAF) [25], linking one successful cooperation to a new area of research.

Study's limitation

While this study evaluates primarily whether cooperation between the aviation industry and academia is taking place, it does not consider the intensity and the success of the cooperation. A shortfall in the results of the exposition is, that it primarily focuses on the beginnings of the collaborations that have been reported in literature, but little evidence is publicly available on the collaboration outcomes and their sustainability. A detailed quantitative analysis would be needed to obtain the state of success of the various collaboration initiatives. Thus, further research is foreseen towards the evaluation of the cooperation and their intensity measured on company size and financial benefit. Yet another weakness of this study to be considered, is that research was carried out in English language resources only. Given the diversity in European languages, further relevant information in the respective languages may have been found, yielding more even more cooperation is taking place than portrayed within this study.

Discussion & Conclusion

The purpose of this quantitative study is to contribute to scientific literature of UIC and provide evidence of activities in the aviation industry. It can serve as an example or methodology to evaluate also collaborations in other technology intensive sectors. This study proves, that players in the aviation industry in Europe are aware of the UIC model, equally utilizing research and education partnerships for their competitive advantage. There is a clear trend towards new technologies being jointly researched and developed and also the talent pool being educated according to industry needs. The collaboration patterns show that there is a preference in collaborating in the companies' home countries, which can be explained through the physical proximity of cooperating team members, reduction in language and cultural barriers, but also access to easier regional funding schemes.

The EU's UBC study shows that 98% and 99% of academic, respective business collaborators already in partnership expect to continue with a partnership [4]. With these facts in mind, an increase in cooperation between industry and academia can be expected in the years to come. Those aviation partnerships in place will likely remain and new incentives under the EU's Aviation Vision 2050 will increase and intensify over time. Policy and financial

incentives have been laid out on national and European levels. To what extend other industry sectors follow the UIC model has yet to be determined. It is likely that those industries of critical infrastructure and of high economic, environmental and of national security interest are being financial support to a greater extend and hence provide higher incentives for cooperation.

Soft factors such as initiating, mediating and managing partnerships are up to the entities involved. Organizational capacity building for running efficient and effective cooperation models remains a fundamental obstacle. Cultural differences among the cooperating organizations require leadership skills and vision to build dynamic teams or sup-organizations. Aims of cooperation partners need to be aligned with each other in order to fulfil the mission of the project.

In conclusion, players in the aviation industry are partaking in the current trend of UIC and have established in part sophisticated networks of partnerships. The area of research focuses more on the long-term cooperation with high investment intensive technologies, also with an international focus. Establishing joint research institutions is hereby an attractive organizational model. Cooperation in the area of education tends to remain more local with mid to long term partnership ties. Dual education systems as seen in the German speaking countries play an important part in this type of cooperation.

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11. Thermal Insulation Solutions for 3D Printed Houses

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1.1 Purposes

When it comes to printed houses the focus is more on the technology of the printers rather than the characteristics of the houses they are able to create. It must be understood that printers are tools and the materials are the key to developing projects using this technology. Based on the materials and their characteristics we will be able to solve questions regarding the legislation and standards required for these constructions in order to obtain the necessary building permits. The research aims understand and to test how to insulate a wall made with a 3D printer, in order to comply with the ČSN 73 0540-2:2011 standard in force in the Czech Republic.

Introduction

Thermal insulating materials are applied to all buildings to ensure a good microclimate, and 3D houses are certainly no an exception.

To ensure adequate insulation for this type of house, attention must be paid to the materials to be used, which can completely change the way the house can be printed.

The material considered in the study with which we will make the printing strips is printable concrete with the addition of additives as a plasticiser. This makes it possible to define in advance the parameters required for the new technology, in terms of the width of the cavity where the insulating layer is applied, and the thickness of the strips that are printed by the machine.

Indoor microclimate parameters are important and we will understand better how work also for the construction of the future that are realize by the printing technology.

All the necessary calculations were carried out, taking into account the regulations in force in Czech Republic according to the thermal dispersion and insulation coefficient.

This document illustrates how this type of construction can be insulate and how the requirements standard ČSN 73 0540-2:2011 can be fulfilled with this technology.

Materials

The material normally used by the 3D printer has the characteristic of being exceptionally fast-drying, allowing it to form a series of overlapping layers without collapsing on itself.

More and more materials are being tested for use by printers and today the real challenge for many companies is how to make a specific material printable.

The first material that was used and is still the most popular today is dry mortar mix which comes in the form of a powdered compound. The mixture consisting of cement, sand, minerals and functional additives. For its use, it only need to add the right amount of water, so that it can be printed directly from the machine.

The very high cost per m3 of this material has pushed the market to look for alternatives and more eco-friendly options.

Numerous experiments are carried out on a wide range of materials. It can start from classic concrete, Geopolymer, or epoxy compounds up to composition of 100% natural materials.

Fig. 1 insulation in the wall cavity (source: Andrea Palazzo 3D wall by Rupp Gebäudedruck)

The Italian Company Wasp has done for the realisation of an Eco Building (Gaia-Ricehouse), an earth compound using of 25% of soil (30% clay, 40% silt and 30% sand), 40% from straw chopped rice, 25% rice husk and 10% hydraulic lime, which has been mixed to make it printable.

Much progress has also been made in the use of geopolymers which is which is an inorganic material that simulate the chemistry of natural rocks that is created by a chemical reaction, between a reactive powder and a saline liquid. Thanks to their exceptional performance, combined with their great variability and 'naturalness', geopolymers represent building materials of the future that combine maximum environmental and structural safety.

Also Epoxy is one of the new product that companies are try to use with 3D printer, but still ever think is in process of study.

One of the latest news reported was the prototype built by engineers at the University of Maine who have succeeded in building the first 3D-printed wooden house made exclusively of bio-based materials. BioHome3D is the name of the project and a mixture of wood fibres, bio resins and blown cellulose was used to realise it. This mixture not only has the characteristic of being bio friendly, but also provides good thermal insulation for the house shell.

Even if we have a number of good alternatives that are being tested for new materials and composites, today, in order to ensure that 3D technology for houses continues on its way to creating not just prototypes, it is necessary to use materials that are available and that have a whole series of characteristics that are well known.

In the list of materials, we cannot forget that we can also use classic concrete for construction: cement + sand + gravel + water. Even if we cannot consider this material environmentally friendly, we must consider that this technology is able to reduce the amount needed to build a house compared to classic monolithic concrete construction.

The advantage of reducing the amount of material required for construction makes this technology an environmentally friendly way of building, reducing the amount of concrete on the construction site and consequently also CO2 emissions.

Concrete has the great advantage of being a well-known material, which makes it much easier to create possible certifications in the use of this material in the field of printer technology.

Even if cement mixed with its components (sand, gravel, and water) do not have the consistency and characteristics to be printed, there are additives on the market that act as plasticisers, which make this material ready for printing.

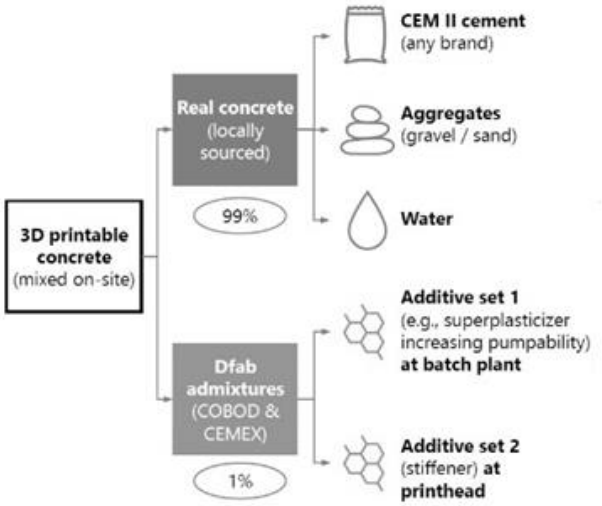


Fig. 2 scheme of the components required to print the concrete (source: COBOD International)

A well-known additive in the market was created by CEMEX multinational building materials company in collaboration with the Danish company COBOD who created the digital (D) fabrication (fab) in concrete: D.FAB additive.

Studies done by CEMEX show that the D.fab admixture performance of the concrete compared to conventional concrete, making the 3D printed concrete more durable.

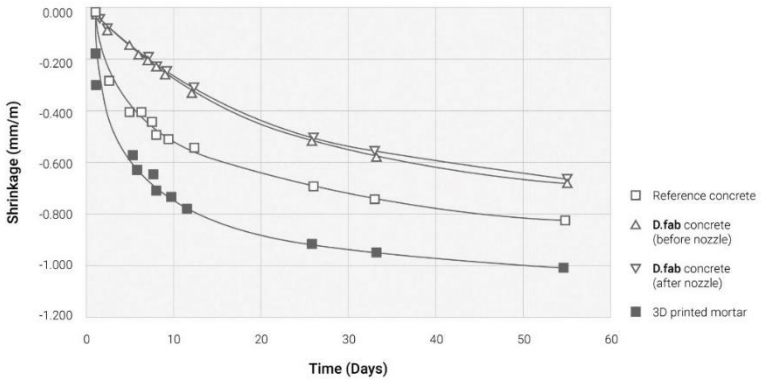


Fig.3 D.fab admixture performance (source: CEMEX Innovation Holding AG)

This is the ideal starting point for presenting to administrations and customers that printed houses are safe constructions and are ready to enter the housing market and everyday life.

Construction Method

First of all, it is important to understand that the study and the parameters we will consider refer to a 3D construction executed in concrete. This means that the parameters could change when using other printable materials. This is because each material would have a different coefficient.

The printed house has a skeleton made of pillars and beams that ensure the stability and statics of the building, the difference lies in how the walls are made it, means that the concrete walls instead of being cast into the formwork, are printed.

The characteristic feature of moulded walls is that, differently from concrete casting which creates a concrete monolith, printed walls create a cavity in between.

The interspace, on the other hand, allows us to have additional advantages such as:

- hide including load-bearing skeleton of the construction
- place installations
- the possibility of leaving the raw printed material visible
- place the thermal insulation

During the execution of the walls, we will realise all the installations. This gives us the great advantage of no longer having to demolish and rebuild the walls several times. In this phase, the laying of the material that will provide thermal insulation is carried out.

This means that having everything hidden inside the walls means that the facades can be left unfinished with their fascinating strip structure.

Obviously it is not forbidden to use on the printed walls material as plaster or to clad with materials such as wood, marble or stone, but since there is no longer an external insulation coat that must be protected by one of these materials, the unfinished structure can remain visible, bringing a great advantage in terms of saving construction costs.

If we wanted to build a construction using this technology, it would be necessary to define a material that has thermal characteristics and can be inserted into the cavity created between the two lines.

Depending on the characteristics of the insulation material and the material used for printing, we will be able to work out the required wall thickness of the 3D construction. The result should comply with the standard coefficients of ČSN 73 0540-2:2011 for residential houses in force in the Czech Republic.

Calculation of heat transfer through a multilayer structure and temperature course in the structure:

Calculation Heat transfer through a multilayer structure allows to determine the thermal resistance and heat transfer coefficient of the structure.

Thank to this we can compare the result with the requirements of the current standard ČSN 73 0540-2:2011. This standard specifies requirements for heat diffusion through structures at three levels - required, recommended and suggested for passive houses.

As it is necessary to meet the energy performance requirements of buildings according to the Law N. 406/2020 Coll. at the same time, the results is compared with the recommended values of heat transfer coefficients.

The reference values for heat transfer coefficients for residential buildings recommended according to ČSN 73 0540-2:2011 standard is:

Urec,20 [W/(m2.K)]

The required and recommended values of heat transfer coefficients according to the currently valid standard ČSN 73 0540-2:2011 are given in the following table.

Tab. 1 – Required value, recommended values and recommended values for passive house of heat transfer coefficients of some structure according ČSN 73 0540-2:2011 (source : ckait)

Description of the construction	Heat transfer coefficient [W/(m2K)]		
	Desired U values $U_{n,20}$	Recommended U values $U_{rec,20}$	Recommended U for passive house $U_{pas,20}$
Outer Wall	0.30	heavy 0.25/light 0.20	0.18 to 0.12
The roof is steep over 45°	0.30	0.20	0.18 to 0.12
Flat roof and sloping roof up to 45°	0.24	0,16	0.15 to 0.10
Ceiling with floor above outdoor area	0.24	0.16	0.15 to 0.10
Ceiling under unheated ground (with roof without thermal insulation)	0.30	0.20	0.15 to 0.10
Wall to unheated floor (with roof without thermal insulation)	0.30	heavy 0.25/light 0.20	0.18 to 0.12
Floor and wall of the heated space adjacent to the ground	0.45	0.30	0.22 to 0.15
A wall between neighbouring building	1.05	0.70	0.5
Filling the opening in the external wall and steep roof from the heated space to the outdoor space, excluding doors	1.50	1.20	0.80 to 0.60
Sloping filling of the opening with a slope up to 45° from the heated space to the outdoor environment	1.40	1.10	0.90
Door filling of the opening from the heated space to the outdoor environment (including the frame)	1.70	1.20	0.90

There are many materials that can be used to insulate printed walls such as:

EPS

Neopor

Rockwool

Polyurethane

For our study we will use the EPS and try to figure out the minimum cavity size necessary to comply with the Czech standard ČSN 73 0540-2:2011

The other parameter to be considered are the coefficients of the concreate printed walls and their thermal resistance and thermal phase shift characteristics, which we find in the following table:

Tab. 2 – Thickness of the layer vs Thermal phase shift (souce: COBOD International)

	Total concrete thick-ness	Thermal Resistance		Thermal Phase Shift
	10 cm / ~4 inches	0.04 m2*K/W	0.23 ft2*h?°F/ BTU	2 hours, 20 min

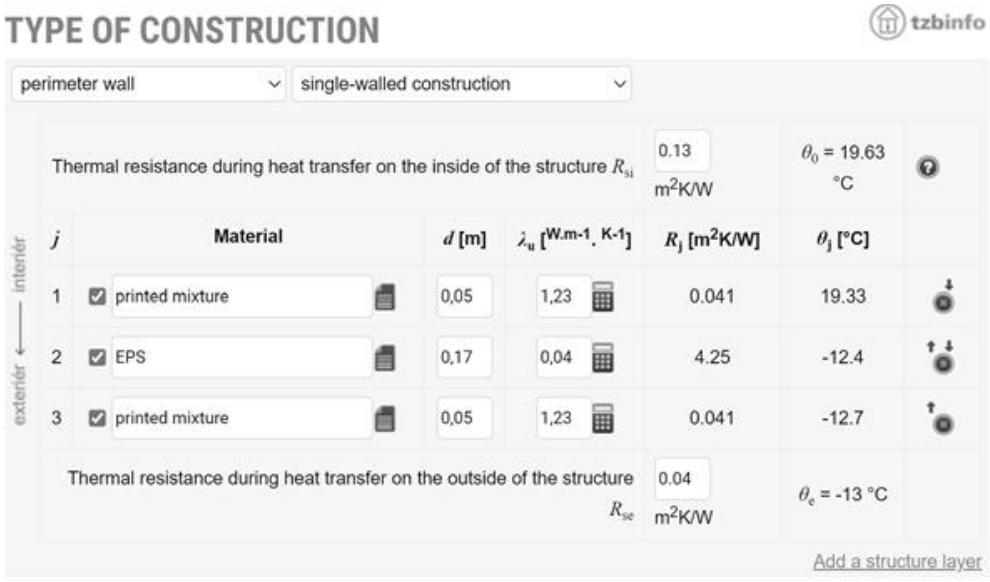
Based on the table received from COBOD International, we were able to make the following observations:
Recommended value in the Czech Republic according to ČSN 73 0540-2:2011

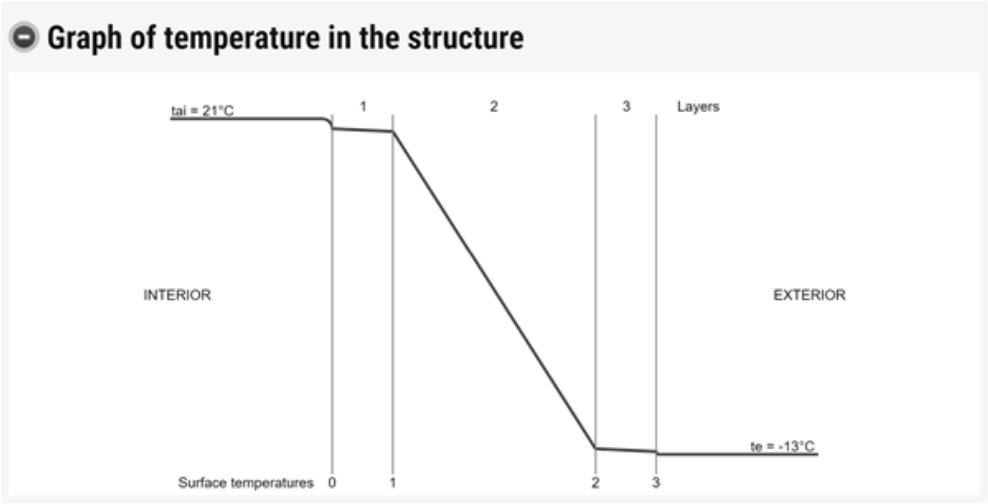
$$U_{rec,20} = 0.25 \ \ W.m\text{-}2.K\text{-}1$$

Calculations verified with specialised programme with:

EPS cavity 170cm, 5 +5 cm printed layers

Tab. 3 – Calculation of the Heat transfer coefficient of the structure using a calculator (souce: TZB)





To finalize the calculation we will add ΔU that represents the surcharge for systematic thermal bridges, due to the presence of wall ties connecting the two parts of printed walls.

With **ΔU = 0.03 is final U = 0.25 W.m^{-2}.K^{-1}**

Heat transfer coefficient of the structure *U* = 0.25 W.m^{-2}.K^{-1}

COMPLIES with the recommended value U_N = 0.25 W.m^{-2}.K^{-1}

According to ČSN 73 0540-2:2011

Conclusion

The result of the research study shows that with a minimum thickness we can achieve sufficient values to maintain the temperature at a comfortable level, but also the possibility of gaining space inside the home by having thinner walls.

This means that if we used the wall thicknesses of conventional building construction in 3D printed constructions we would be able to lowering drastically the value of the heat transfer coefficient U.

The dimensioning of the thermal insulation for the system of external walls in the 3D-printed house was evaluated to the recommended values of the standard ČSN 73 0540-2:2011, which ensures the basic prerequisite for meeting the energy performance of the proposed houses according to Law No. 406/2000 .

It is obvious that there are also other factors that need to be taken into account such as the type of windows, the way the roof is built and insulated, the heating system, the exposure to the sun, the type of lighting, and all the technologies that guarantee the standards of everyday life in order to meet the energy performance requirements of buildings.

But as far as vertical elements are concerned, there are good future prospects. All this considering that the material we tested is concrete, which has no thermal-acoustic qualities. So things could be very different if we can print a material with good thermal characteristics.

The real challenge in this field and for this technology will be to find high-performance printable materials with better thermal coefficient. These characteristics will further help the thermal performance of the houses of the future, which will be more and more environmentally friendly.

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12. Financing Options for Water Supply and Sewage Systems in The Czech Republic

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Abstract

Building technical infrastructure significantly contributes to the development of communities and cities. In the case of constructing water supply and sewerage networks, commitments to the EU community are fulfilled. This contribution deals with a clear description of co-financing options for the construction of new or expansion of existing water supply or sewerage networks in municipalities in the Czech Republic.

Keywords

Water supply; Sewage system; Grant; Municipalities; Financing.

Introduction

In the Czech Republic, according to statistical data from 2022, approximately 461,000 (4.4%) people were still not connected to the water supply network, and nearly 1,338,000 (12.7%) people were not connected to the sewerage network. Although this does not necessarily mean a violation of legislative obligations, it indicates significant potential for future construction of these technical infrastructures, particularly in municipalities responsible for managing the water supply and sewerage network. .[1][2]

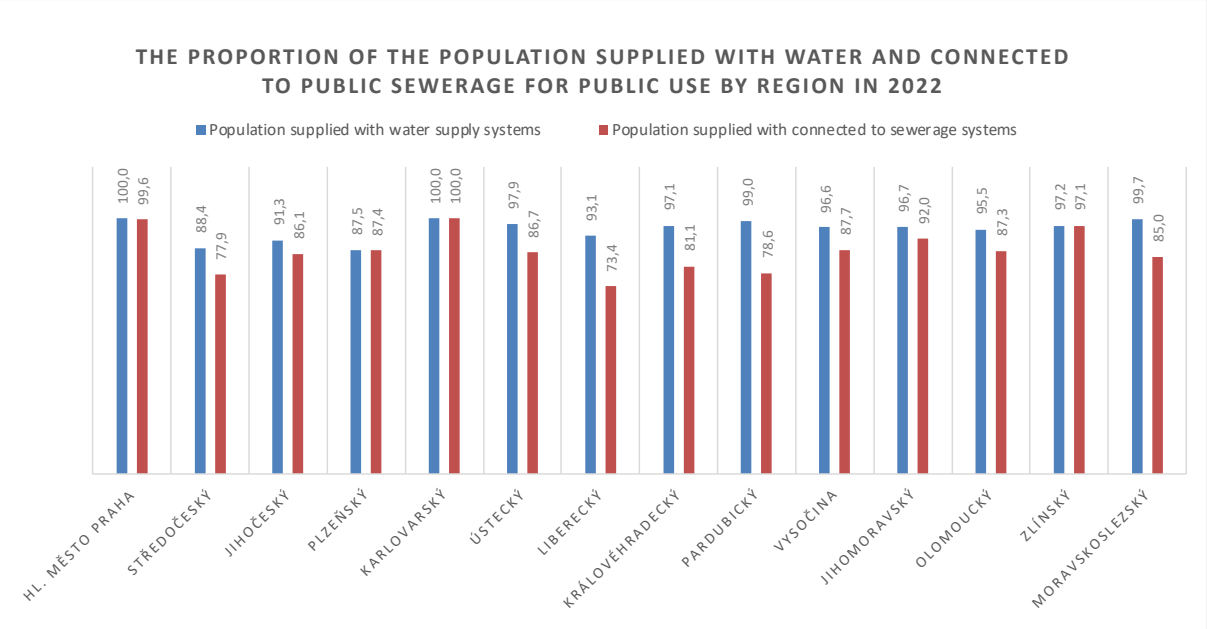

Figure 1 The proportion of the population supplied with water and connected to public sewerage for public use by region in 2022 (*source: author with the use of [5]*)

A reliable and accessible public water supply and sewerage network bring the advantage of a constant supply of quality drinking water to municipalities and reduce the discharge of polluted wastewater into surface or groundwater, to which we have committed as a community by adopting Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.[3][4]

In addition to these benefits, the existence of technical infrastructure also contributes to the development of communities and cities, serving as a necessary requirement for the emergence of new residential areas. For legislative reasons, for instance, every new family house must have a wastewater disposal system, leading to the necessity of acquiring a domestic wastewater treatment plant in municipalities without a public sewerage network. Therefore, the existence of public infrastructure signifies a competitive advantage for municipalities seeking investors for new construction.

The construction of technical infrastructure can be very costly for the municipalities themselves, and logically, the cost increases with the area. Particularly for small municipalities, the economic aspect of the project often becomes unsustainable given their budget constraints. It is observed that precisely small municipalities (with up to 500 inhabitants) frequently do not have a water supply or sewerage network established. Moreover, apart from the competitive advantage, public interest takes precedence in the construction of a drinking water supply system or a system for sewage and wastewater treatment, thereby offering financial co-participation from the state or the region. Primarily, the state utilizes the opportunities provided by the European Union through operational programs, with these funds further being channeled through individual ministries via grant calls.

Cohesion Fund EU

The Ministry of the Environment utilizes this fund for the Environmental Operational Programme. Between the years 2014 to 2020, a total of 2.75 billion euros was made available for applicants through this operational program. For the new period from 2021 to 2027, an additional allocation of 61 billion CZK (approximately 2.45 billion euros) has been allocated. [6] [7]

The Operational Program primarily relates to projects related to the protection and provision of a quality environment for the inhabitants of the Czech Republic, limiting the negative impacts of human activities on the environment and climate, and contributing to solving environmental and climate issues at the European and global levels. The program is divided into specific objectives for the period 2021 to 2027. Specifically, for supporting the construction of new water supply and sewerage networks, a specific objective 1.4 "Water Supply and Sewerage" has been allocated approximately 14 billion CZK. In practice, if a project plans for the construction of both networks, the application for a grant for the sewerage network is requested first. If the grant for the sewerage network is approved, it becomes easier to obtain a grant for the water supply network as well. [6] [7]

Grants are redistributed every year through calls, either continuously for simpler projects or competitively for all types of projects, which can be applied for by municipalities or voluntary associations of municipalities, or business associations that own at least 50% of the public entity. During the period 2014 to 2020, grants were provided for a maximum of 85% of all eligible expenditure of the construction project. For projects generating profits, such as sewage or water supply networks, the income is subtracted from the total eligible expenditure, and the grant amount is then 63.75%. In the current operational program for the years 2021 to 2027, it is possible to obtain a grant of 70% for new construction and 30% for the intensification of wastewater treatment plants (WWTPs) in this specific objective. Grant approval is based on the application for a grant, where the Ministry of the Environment checks the formal completeness and general and specific eligibility of the application and subsequently conducts a substantive evaluation. [6] [7]

The grants in water management from the Ministry of Agriculture

The Ministry of Agriculture offers a range of grant programs aimed at supporting water supply and sewerage networks or other water management structures. The "Support for the construction and technical enhancement of infrastructure and sewers" program serves to support the construction of water supply and sewerage networks in smaller municipalities in the Czech Republic. This program is intended for municipalities or local parts of cities with up to 2,000 inhabitants to support the construction of new water supply systems, sewers, water treatment facilities, or wastewater treatment plants (WWTPs). In the case of expanding a water supply or sewerage network, the project must be for a minimum of 50 inhabitants. The Ministry of Agriculture issues this program almost every year in a new installment, and for the water supply and sewerage network, the grants are divided into sub-programs, so it is necessary to apply for grants separately. [8]

- **Sub-program 129 412** is intended to support the construction of water supply systems to ensure the supply of drinking water to the population.
- **Sub-program 129 413** is aimed at supporting the construction of sewerage systems and wastewater treatment plants to achieve the necessary level of wastewater collection and treatment.

Support is provided in combination with "investor's own resources," with a maximum grant amount of 50 million CZK, and the grant amount should not exceed 70% of eligible costs. Investors participating in this program can be municipalities, municipal associations, or water management companies, of which 90% is owned by the municipality or city, and also organizations directly subordinate to the Ministry of Agriculture. For sub-program 129 412, the maximum eligible costs must not exceed 100,000 CZK without VAT per 1 permanently registered inhabitant. If a water treatment plant or feeder is built together with the water supply, the maximum amount is 110,000 CZK without VAT. For sub-program 129 413, eligible costs must not exceed 150,000 CZK without VAT per one permanently registered inhabitant. If, in addition to the new sewerage, a new WWTP is built, eligible costs can be

up to 165,000 CZK without VAT. Eligible costs include only direct implementation costs for the construction of water supply, sewerage, and their facilities. On the other hand, expenses for preparation and securing the action, project documentation, connection costs, or costs for sewers leading to recreational development are not considered eligible costs. [8]

Regional grant programs

Each region in the Czech Republic supports municipalities in finding solutions for drinking water supply and wastewater management through grants provided from the regional budgets. Such grants are usually conditional on participation in the aforementioned grant programs and complement these grants. For example, the Central Bohemian Region annually announces grant programs aimed at supporting regional development. The Central Bohemian Infrastructure Fund is divided into two thematic tasks. The thematic task "Environment" is designated for the construction of water supply or sewerage networks. In this case, only a municipality or association of municipalities located in the Central Bohemian Region has the right to be granted the subsidy. Similar conditions apply to the grant programs of other regions. The maximum grant in the thematic task "Environment" is 5,000,000 CZK, with the recipient's minimum co-financing required to be at least 15% of the total eligible costs. [9]

Conclusion and discussion details

Municipalities without established technical infrastructure (water supply and sewerage) on their territory increase the construction costs for investors in residential buildings or houses, as they have to individually address drinking water supply or wastewater management in their projects, such as wells and domestic wastewater treatment plants. As a result, municipalities may lose potential inhabitants who would contribute to their development. Moreover, in connection with the housing unavailability in larger cities, there is a growing demand for housing in the regions. However, statistics show that especially the Central Bohemian Region, which is a potential destination for people working in the capital city of Prague, has significant gaps in this regard. The regions of Plzeň, Ústí, and Liberec are not lagging behind either.

Projects for the construction of water supply or sewerage networks cannot be planned on a short-term scale, as substantial project preparation must be completed even before the application for a grant. The persistent issue of the length of permitting procedures in construction also plays a role. It is, therefore, necessary for municipalities to be more proactive in this regard, with support from both regions or the state and the residents of the municipalities, as the value of properties for existing residents increases with the construction of technical infrastructure.

Although infrastructure construction can be costly for municipalities, the described grant programs are generous, and recurring grant calls on an annual basis reduce the risk that the initial investment in project preparation could be thwarted. The long-term added value of the project will then bring a return on investment to the municipality.

The more advantageous grant program is that from the Ministry of the Environment, as it has a broader focus in terms of cost coverage and potential applicants. Supplementary regional grants are then used to cover primarily the costs of project preparation, including studies. It should be noted that the current operational program has a limited period within which the project must be implemented by the end of 2029.

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13. Reducing Energy Poverty: The Role of Sustainable Construction in The Czech Republic

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Abstract

The aim of the article is to examine the relationship and impact of the current construction pace on energy poverty in the Czech Republic. Energy poverty represents a significant social issue that worsens with rising energy prices. People living in energy poverty often lack the means to improve their situation, which stems from the high energy demand of their housing or the inability to acquire more energy-efficient homes. Within the project, an analysis was conducted to assess the potential contribution of sustainable construction to reducing energy poverty.
Computations utilized a household model in the Czech Republic, and based on selected parameters, a sensitivity analysis was performed, exploring the sensitivity of the calculation to the established energy poverty threshold. Following the obtained results, an estimate of the future number of energy-poor households was made. The forecast was based on two main factors: the development of household energy costs and the progress of building renovations in the Czech housing fund. An evaluation of the percentage increase in energy prices concerning the total number of households spending more than 10% of their incomes on heating was carried out. The price forecast was established based on consumer price indices determined by the Czech Statistical Office.

Keywords

Energy Poverty; Energy Efficiency; Sustainable Construction

Introduction

The European Commission has proposed a plan to achieve climate targets by 2030 [1], aiming to reduce net greenhouse gas emissions in the EU by at least 55% compared to 1990 levels. Energy efficiency is a key component of these measures, with one area requiring significant effort being the construction sector. To achieve the goal of reducing emissions by 55% by 2030, the EU should decrease greenhouse gas emissions from buildings by 60%, their final energy consumption by 14%, and energy consumption for heating and cooling by 18% [2]. It is therefore crucial for the EU to focus on making our buildings more energy-efficient, less carbon-intensive throughout their life cycle, and more sustainable. Implementing principles of "circularity" in building renovations will reduce greenhouse gas emissions from materials used in buildings [3].

Currently, only 11% of the existing building stock in the EU undergoes a certain level of renovation annually. However, renovation efforts rarely focus on the energy efficiency of buildings. The annual rate of significant energy renovation is low, approximately 1%. Across the EU, extensive renovations that reduce energy consumption by at least 60% are carried out in only 0.2% of the building stock each year, and in some regions, the rate of energy renovation is practically nonexistent. At this pace, achieving carbon emissions reduction in the construction sector to net-zero levels would take centuries. It is time to take action [4].

At stake is not only the minimization of energy bills and reduction of emissions. Renovations can open a myriad of possibilities and bring far-reaching social, environmental, and economic benefits. Thanks to renovations, buildings can become healthier, more environmentally friendly, interconnected within neighborhoods, more accessible, resilient against extreme natural phenomena, and equipped with charging stations for electric vehicles and bike parking. Smart buildings can offer essential data for urban planning and service provision in cities, all while respecting privacy concerns. Extensive renovation efforts can alleviate pressure on new construction on greenfield sites, aiding in the preservation of nature, biological diversity, and fertile agricultural land.

In line with the Clean Energy for All Europeans package, member states must utilize their national energy and climate plans and long-term renovation strategies to identify buildings where individuals threatened by energy poverty reside. They should prioritize developing effective strategies for their renovation. Concurrently, with this communication, the Commission presents recommendations on energy poverty, providing guidance to member states in defining and implementing these strategies aimed at reducing energy poverty [5], [6].

Methodology

The research discussed in this article employed a mathematical modeling method to characterize energy poverty in Czech households. The model aimed to determine the number of energy-poor households and illustrate the structure of energy-poor households in the Czech Republic.

This model utilizes the principles of stochastic modeling. Based on acquired statistical data, probabilities of specific household characteristics were determined. Subsequently, the model generates the quantities of households that characterize the Czech Republic. The model operates with a set of generated data files, allowing for discrepancies to be incorporated into the model's outcomes. Data from the 2021 Census of Population [7], Houses, and Apartments by the Czech Statistical Office were used for the model, supplemented by data from Eurostat [8] and from the ENERGO survey [9], [10].

The stochastic model was chosen to expand the model's working capabilities and due to imperfections in the input data. The aim is to most accurately approximate real events and encompass various combinations of input data that can occur in reality.

The model operates at two levels of random variables. The first level involves generating random households based on the probability of their characteristics, such as household composition, type, and location. At the second level, these generated households are supplemented with statistical data, randomly selected from a predetermined

range (e.g., household income). After generating these random variables, the model utilizes a deterministic method to calculate the remaining variables necessary for the household in the final evaluation.

Results

The first output of the model provides an overview of the overall representation of households affected by energy poverty in the Czech Republic. An energy-poor household is defined as one that spends more than 10% of its income on heating the building. Based on the estimated occurrence of energy-poor households in the Czech Republic, it is possible to determine the number of households that meet this criterion. Considering that there are currently 4,813,103 households in the Czech Republic, there are a total of 731,600 to 950,100 households that can be characterized as energy-poor households.

The outputs of the model not only include estimates of the occurrence of energy poverty in the Czech Republic but also allow for data to be displayed based on input parameters. This means that it is possible, for example, to calculate the number of energy-poor households in individual regions or assign the numbers of energy-poor households to categories such as household head, household members' education level, building type, building age, etc.

The development of the number of energy-poor households in connection with building renovations was estimated based on two main key factors: the increase in household energy costs and the progress of building renovations within the housing fund of the Czech Republic. A survey was conducted on the percentage increase in energy prices concerning the total number of households spending more than 10% of their income on building heating. Predictions regarding future price developments were made based on consumer price index figures determined by the Czech Statistical Office.

Considering the expected development of energy poverty, a price index for heating was set at 216.29% for the year 2030. If we only consider the increase in prices, it is expected that 43.61% of households in the Czech Republic will be considered as energy poor. This situation would occur assuming household incomes remain the same. However, if we also anticipate income growth, the number of households affected by energy poverty will increase. This is because the household income growth index for 2030 is lower than the energy price growth index, which was set at 186.77%. Both scenarios are compared to the year 2018 as the reference point. Taking income growth into account, it is expected that in 2030, 21.71% of households will spend more than 10% of their income on heating.

Considering the anticipated developments in the housing sector, where gradual reconstruction of residential buildings is expected, an additional parameter characterizing the extent of housing fund renewal was included in the calculation.

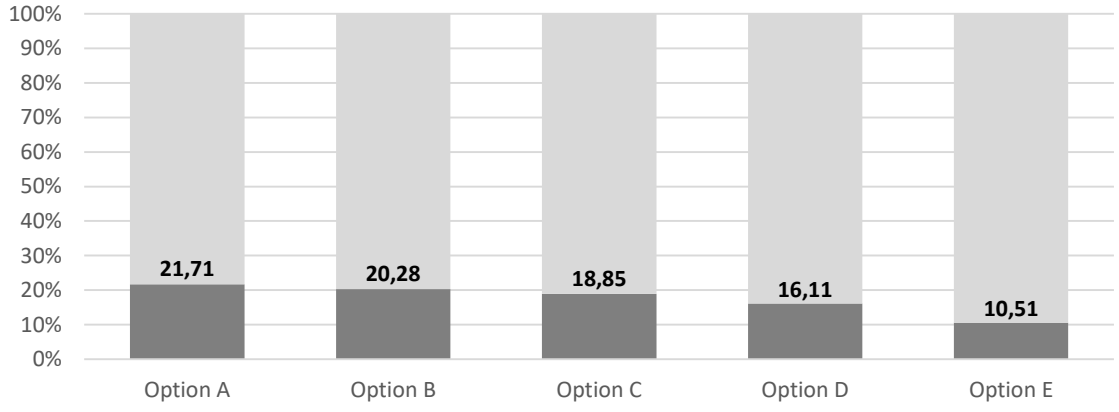

Figure 1: Estimation of energy poor households in Year 2030 in Variant (source: author's model)

Option A represents the basic scenario characterizing the estimation of the development of energy-poor households in the year 2030. The model calculation considers an increase in energy prices by 216.29% compared to the year 2018 and an increase in household incomes by 186.77% compared to the year 2018. For this basic modelling scenario, the estimated proportion of energy-poor households is 21.71%.

Option B is based on Option A but includes information about the transformation of the housing stock. The calculation assumes a 1% annual renovation of the housing stock. This renovation effort is evenly distributed among all properties.

Option C is derived from Option B but assumes a housing stock renovation rate of 2% per year.

Option D is based on Option A but considers a 1% annual renovation of selected properties. The calculation assumes that 80% of all renovated buildings are inhabited by households affected by energy poverty.

Option E builds upon Option D but assumes a renovation rate of 2% per year.

From the previous model results, it is evident that within the current development characterized by Option A, there will be an increase in households spending more than 10% of their incomes on heating expenses by the year 2030. Even considering the current rate of housing stock renovation will not ensure a reduction in energy-poor households. The optimistic Option C, which assumes a renovation rate of up to 2%, leads to an increase in energy-poor households from 17.5% to 18.85%. To significantly reduce energy-poor households, it is necessary to support building renovations, especially for affected households, and promote a housing stock renovation rate in the Czech Republic of at least 2% per year.

Conclusion and discussion

One of the key factors contributing to energy poverty is the poor thermal-technical condition of buildings. It is essential to support investments in improving the energy efficiency of the housing stock in the Czech Republic. Primarily, this will lead to energy savings and related expenditures, contributing to the fulfillment of European energy-saving goals.

These are the main aspects that energy policy should address:

- Building envelope efficiency;
- Efficiency of technical building equipment;
- Utilization of primary energy sources;
- Promotion of renewable energy sources;
- Legislative support for energy communities and the involvement of households in energy flexibility;
- Environmental quality.

Support programs and legislation should also address issues that may arise during the changing global energy market. Energy prices are rising, leading to increased household expenses. This effect is amplified by the growing number of households affected by energy poverty.

Above all, it is essential to highlight the close connections between construction and energy sectors, both in energy consumption (including measures to ensure energy savings in building operation) and in the implementation of plans for the renovation and development of energy capacities within the national energy concept.

Emphasizing the principles of energy-efficient construction will demand continuous preparation and implementation of various innovations in construction firms: technical, technological, organizational, and commercial innovations. In this context, extraordinary demands will be placed on improving the quality of management at the level of individual companies and enhancing the efficiency of the regulatory environment and conceptual coordination by public authorities.

The prerequisites for future developments in energy prices and the need to enhance the energy efficiency of homes will require a robust, efficient, and accessible construction industry. This sector will be one of the key tools for reducing energy poverty in the Czech Republic. It is not only important to create a strategy for reducing energy poverty and adopt it at the national level but also to ensure the availability of strong construction industry tools to assist in achieving the goals for reducing energy poverty.

Considering the requirements of the upcoming wave of renovations, it is inevitable for the Czech construction industry to regain its competitiveness and fully exploit its innovation potential. This process demands a comprehensive transformation of the sector, improvements in the education system, and increased investments in research and innovation. Only in this way can we accelerate the currently insufficient decarbonization of buildings, prepare for the anticipated building renovations, and anticipate the future challenges that lie ahead. It is crucial to approach this task with determination and vision to ensure more sustainable and energy-efficient buildings for our future generations. We firmly believe that this transformation is a pivotal step towards a more sustainable future for our construction industry and society as a whole.

Acknowledgement

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14. Digitalization of subcontractor tender management

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Abstract

With advancing digitization in the construction industry, management processes leading to more efficient employee activities are increasingly digitized in construction companies. The research is focused on the digitization of the tender process in the environment of a construction company.

Keywords

software, digitization, construction company, subcontractor

Introduction

Due to the advancing digitization of the industry, which places ever greater demands on the up-to-datedness and rapid availability of data, the digitization of construction companies is an inevitable milestone in the future operation and maintenance of competitiveness. In the case of large construction companies, digitization is a crucial milestone for streamlining processes given the distances between construction projects and company headquarters.

Digitization itself brings advantages, especially in the construction industry, in the form of speeding up approval processes and more efficient extraction of data for decision-making processes.

Methodology

The aim of the thesis is to research the benefits of digitization of repetitive processes in a selected construction company and its possible further use. The ever-repeating process of evaluating subcontractor selection on construction projects was chosen for the research. In the case study, a chronological set of activities is defined for the compilation of the tender evaluation and approval by the responsible staff in a real environment without digitization and after digitization.

Supply system

The supplier system is chosen with regard to the type of construction project and the amount and details of information about the project at the start of the tender process. By determining the supply system, contractual and organizational security is established to ensure the project's goal. The supply systems themselves differ mainly in terms of the degree of risk for the investor and the contractor. Supplier systems are further divided into a single supplier system and a multi-supplier system.

Process innovation

As part of process innovation, the needs of the company's internal environment are monitored. The very stimuli for innovation can thus come from the employees. Before introducing a new or significant improvement to an existing management process, a study of the expected benefits and costs should be carried out. The process innovation itself should be entrusted to a responsible person who chooses a responsible team. The innovation process itself can be divided into four steps [1]:

1) identification of a weak point for innovation;
2) identify affected groups;
3) find a solution;
4) test the solution;
5) implement a solution.

In the case of testing in a real environment, the trial of the solution may intermingle with the original process solution, and therefore it is advisable to choose the test environment and the team for testing, considering the possible risks of failure and the need to return to search for a more suitable solution.

Currently, thanks to digitization, innovation focuses mainly on the automation of processes that are carried out manually and are constantly repeated. [2]

Selection of a subcontractor

Nowadays, most general construction contractors do not have their own capacity for labour professions and mechanical engineering. Thus, general contractors divide the project into several subcontractors with a focus on

individual professions to maximize profits. All these capacities are part of the subcontracting system, where in the case of choosing a suitable subcontractor, the selection is assessed from the point of view of three main criteria:

- price;
- time;
- quality.

The evaluation criteria can also be supplemented with, for example, reliability, size of capacities, etc. In the event that the subcontractor is selected well in advance of the actual implementation, the decisive criterion is in particular the bid price. [3]

In the case of large corporate companies, the selection of subcontractors is the subject of a so-called tender process, which is governed by internal guidelines, which determine, for example, the minimum number of prices offers from subcontractors according to the threshold value of the tender process and then the approval process of the tender process itself. The selection of the subcontractor takes place within the project team on the construction projects themselves or is managed centrally.

Case study

The case study is focused on the digitization of the approval process of the subcontractor's selection procedure in an unnamed construction company. When processing the evaluation of the selection procedure, in the case of manual filling in, the entire procedure is processed using a Microsoft Excel spreadsheet and is then physically printed and approved. The entire manual process is replaced by a web application containing a database of subcontractors including contact persons and an approval matrix.

As part of the study, a comparison of the process divided into activities before digitization and after digitization of processes is carried out, including an evaluation of process streamlining.

Case study no.1

In the first case study, an analysis of the activities related to the processing of the tender evaluation is carried out. Due to the automation of the creation of new tenders, the process of assigning a tender number is fully automatic and thus numbers cannot be duplicated. In the case of entering information about subcontractors in the evaluation for comparison of bids, all information about subcontractors is filled in automatically from the system database. Based on the selection of the most suitable offer using the check box, the winning subcontractor is automatically filled in, and according to the size of the offer price, all approvers are filled in.

Table 1: Case study no. 1 (source: author)

bez digitalizace			s digitalizací		
počet činností	**název činnosti**	**manuální (M) /automatické (A)**	**počet činností**	**název činnosti**	**manuální (M) /automatické (A)**
1	Vyplnění názvu výběrového řízení	M	1	Vyplnění názvu výběrového řízení	M
2	číslo výběrového řízení	M	2	číslo výběrového řízení	A
3	mezní hodnota	M	3	mezní hodnota	M
4	odbytová hodnota	M	4	odbytová hodnota	M
5	vyplnění popisu výběrového řízení	M	5	vyplnění popisu výběrového řízení	M
6	termín realizace subdodávky	M	6	termín realizace subdodávky	M
7	Název subdodavatele	M	7	Název subdodavatele	A
8	Kontaktní osoba subdodavatele	M	8	Kontaktní osoba subdodavatele	A
9	kontakt na subdodavatele	M	9	kontakt na subdodavatele	A
10	Cenová nabídka	M	10	Cenová nabídka	M
11	Poznámka	M	11	Poznámka	M
12	Vítězný subdodavatel	M	12	Vítězný subdodavatel	A
13	Schvalující osoby	M	13	Schvalující osoby	A

Based on the comparison of manual and automatic activities listed in TAB No. 1, it is evident that in the case of a digitized process, the creation of a tender evaluation is six process steps faster due to digitization. In the case of the digital database of subcontractors, filling in the subcontractors itself is done using a drop-down list with a so-called whisperer, when after selecting a supplier, the contact person, including contacts, is automatically filled in.

Automatic filling in of approving persons is carried out based on pre-set conditions determined by the approval matrix based on internal company guidelines when the basic criterion is the tender price of the subcontractor.

Case study no. 2

The second case study describes the approval of the tender of the contractor before the conclusion of the contract for the work. According to internal company guidelines, each tender procedure must be approved by the responsible persons before announcing the victory in the tender procedure to the subcontractor.

Table 2: Case study no.2 (source: author)

bez digitalizace		s digitalizací	
počet činností	**název činnosti**	**počet činností**	**název činnosti**
1	podpis výrobního přípraváře	1	podpis výrobního přípraváře
2	podpis vedoucího projektu	2	podpis vedoucího projektu
3	převoz na vedení společnosti	3	podpis vedoucího nákupu
4	podpis vedoucího nákupu	4	podpis ředitele závodu
5	přenos na vedení závodu		
6	podpis ředitele závodu		

If we compare the approval process of approval before and after digitization, the whole process is two steps shorter in digital approval thanks to approval through the web application. In the case of an approval process without digitization, it is necessary to print out the tender evaluation, physically sign it at the construction site and then deliver it to the company headquarters for signature, where the document is submitted for signature by the head of the purchasing department and the plant director. Thanks to the digitization of tender approval, it is possible to make comments or approve the tender without the need to travel to the head office. The applicant thus always has an overview of the approval status of the selection procedure and, if necessary, can urge the approver with whom the selection procedure is currently located for a statement.

Conclusion

Following the digitization of the entire industry, the digitization of construction companies is one of the tools for increasing productivity. Following the case studies, it can be said that the digitization of processes itself brings acceleration of approval processes and, as a side effect, brings more options for working with data that can be extracted from digital applications. One of the other benefits is the possibility of carrying out the evaluation of the selection procedure, for example, from home. In the case of tenders, it is possible, for example, to work with data to monitor the workload of individual subcontractors in terms of time and thus minimize, for example, the risk of overloading the subcontractor with a large volume of work in the event of shifting implementation on several construction sites to the same time period. One of the other directions in the development of the web application is the addition of the evaluation of subcontractors after the completion of the work, which can provide the necessary information for other project teams.

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15. Collection And Reuse Of Gas Helium

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Abstract

The increasing operating costs and the desire for a more economical and environmentally friendly approach to pursue scientific research a science are the main reasons for optimization of individual operations. One of them is the capture of already used helium gas that has been used for cooling of instruments, its re-liquefaction and subsequent reuse. When planning the construction of a helium gas reuse system, it is necessary to consider not only the investment made for its construction, but also the operational costs for its re-liquefaction and distribution, and the associated requirements for rezoning and building permits. These individual steps are essential to determine the expected payback period based on which the decision to implement it will be made.

Keywords

gas helium; liquid helium; capture; reuse; liquefaction; economic aspect

The Institute of Organic Chemistry and Biochemistry of the CAS

The Institute of Organic Chemistry and Biochemistry of the CAS, one of the largest and most important institutions of its kind not only in the Czech Republic but also in Central Europe. It is engaged in cutting-edge basic research in the field of organic chemistry, biochemistry and materials chemistry. Several of the Institute's scientific results have been translated into practice in the form of licences and the Institute is thus relatively well financed.

To ensure optimal and efficient functioning of the institute, there are also service departments. Some of them carry out their own autonomous scientific activities in addition to purely service analytical work. Among the latter teams, the Nuclear Magnetic Resonance (NMR), Cryomicroscopy and Scanning Probe Microscope (SPM) Departments should be clearly mentioned. The latter two methods will be put into operation shortly after the completion of the building being built to house them.

The NMR spectroscopy and SPM departments

The NMR spectroscopy department is currently equipped with eight spectrometers. These state-of-the-art facilities are equipped with magnets generating stationary magnetic fields using superconducting coils in the range of 9.4 to 20 Tesla. The magnet structure consists of a cryostat with a superconducting coil inside. For proper functioning of the magnet (maintaining superconductivity), continuous cooling of the coil with liquid helium (primary circuit) and liquid nitrogen (secondary circuit) is required. Similarly, in the case of cryomicroscopy and SPM, both liquid gases are necessary for proper operation of the device. The liquid gases normally evaporate into the atmosphere and therefore need to be replenished periodically.

Tale 1: The nitrogen and helium information (source: Karel Šobíšek)

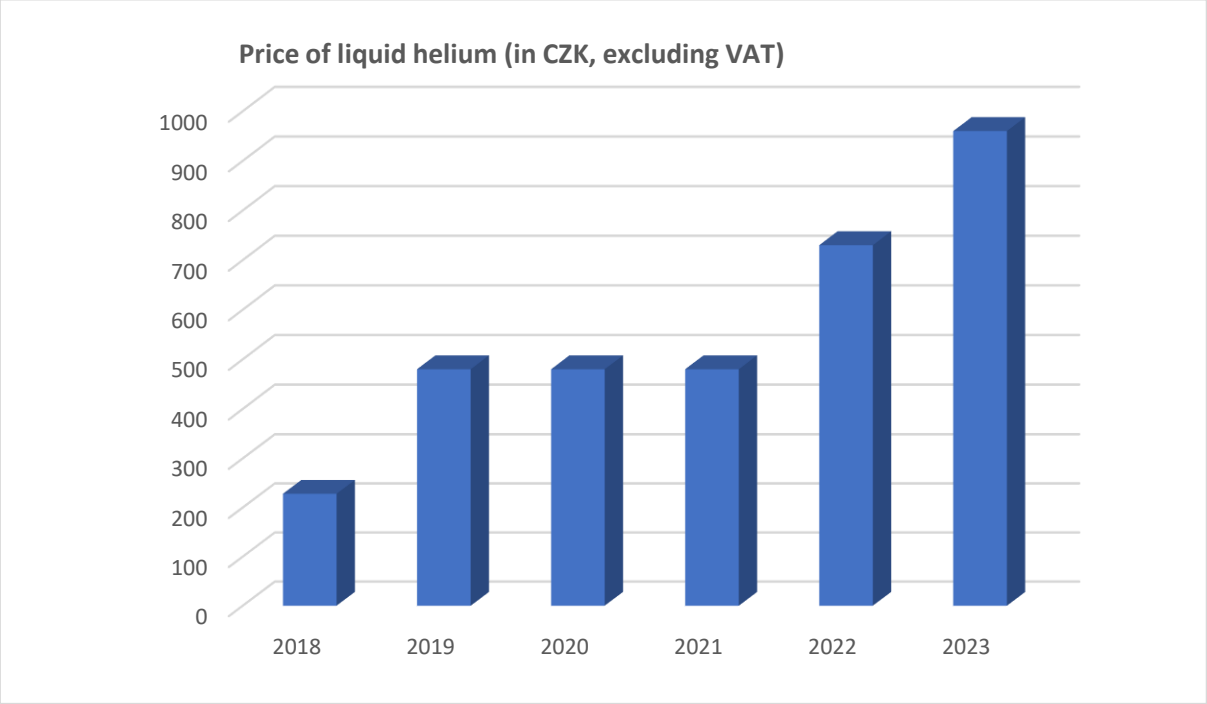
	Content in the air (%)	Boiling point (°C)
Nitrogen	78.1	-196
Helium	5.2e-4	-272

As the attached table shows, the physical properties of these media require specific handling and safety measures. The consumption of liquid helium only for the NMR spectroscopy department is about 3000 litres per year, the estimated consumption for SPM cryomicroscopy is the same and thus the annual consumption of this medium is about 6000 litres. Although the consumption of liquid nitrogen is several times higher, due to its price and the sophistication of logistics at the institute, its eventual storage does not need to be addressed.

Liquid helium

The most important suppliers of liquid helium are currently the United States of America (55% of annual world consumption), Qatar (30%), Algeria (7%), Poland and Russia. Due to the war in Ukraine and political instability in North Africa, the price of a litre of liquid helium has increased very significantly over the last 5 years. As the price chart shows, this increase is more than fourfold compared to 2018. Therefore, given the increase in consumption and the price evolution, it was necessary for the IOCB to think about finding financial savings in the cost of this commodity. Collecting the vaporized gas, liquefying it and then reusing it seems to be the most efficient way.

Graph 1: The Price of liquid helium (source: Karel Šobíšek, IOCB´s acconting)



The recuperation system of gas helium

The principle of the proposed solution

The helium collection system operates as a closed system consisting of a collection piping system, a collection bag, a high-pressure compressor and sets of cylinders. The whole system can then be divided into a low-pressure and a high-pressure part. The low-pressure part is responsible for collecting helium from the individual devices into a collection bag, which is gradually filled by evaporation. In the high-pressure section, this gas is then compressed by a compressor into cylinders.

The low-pressure section

The low-pressure section is responsible for collecting the gas, the gas evaporation is more or less constant. A stainless-steel pipe is used for this purpose, which is connected to the individual instruments via a one-way valve. The dimension of the stainless-steel pipework depends on the requirements of the individual apparatus, and must also take account of the filling phase, i.e. the point at which the evaporation rate is several times higher than in normal operation. For these evaporation fluctuations is used a three-way valve, which connect the piping and the Dewar container containing the liquid helium, the evaporation generated during the cooling of the filling pipes goes directly into the capture pipe. The gas is then pushed into the collection bag by the pressure generated during evaporation. The volume of this bag corresponds to the weekly evaporation of the equipment at the IOCB, with the added capacity for possible expansion with additional equipment.

The high-pressure section

From the collection bag, the gas is compressed by a high-pressure spare compressor into sets of cylinders. After the cylinders are filled to the required pressure, the cylinders are transported for liquefaction. It is necessary to install with a minimum of three sets of bundles:

- first bundle connected to the compressor,
- second bundle designated for transporting compressed gas for liquefaction,
- third a bundle as a backup in case of liquefier failure or as a backup for a broken “second” bundle.

The liquefier

The liquefier for the recovered gas is a separate problem. The liquefier is space and economically demanding. There are liquefiers on the market with different capacities and operating in different modes (continuous, intermittent). Helium liquefaction for the IOCB´s needs could be realized in principle in three ways:

- "in house" liquefaction with own equipment,
- by an external company (e.g. a standard liquid gas supplier),
- finally in a joint project within the Academy of Sciences or with a university.

There is currently no space on the IOCB´s area where a liquefier could be built. Technical gas suppliers operating in the Czech Republic use liquefiers outside the Czech Republic, which makes use those liquefiers extremely uneconomical. In the Czech Republic there are currently liquefiers only in Brno and Prague. Liquefiers in Brno is again uneconomical for liquefaction because of the distance. Finally, the liquefier in Prague is at the end of its technical and economic life.

On the base of the above-mentioned facts, a meeting of several Prague institutions was held which resulted in a project for the purchase of a new liquefaction plant co-owned by three institutions:

- Institute of Physics of the Academy of Sciences of the Czech Republic (FZÚ)
- Faculty of Mathematics and Physics of Charles University (MFF UK)
- Institute of Organic Chemistry and Biochemistry of the Academy of Sciences of the Czech Republic (ÚOCHB)

The estimated cost of the liquefier is estimated at 43 million CZK. The financial participation of ÚOCHB would be 6 million CZK. This would give ÚOCHB 1/7 of the liquefier capacity.

Building options for the implementation of the helium recovery project at the IOCB

The current dense built-up area of the IOCHB site is not favourable to the helium recovery system, especially because of the planned location of the individual instrumentation. The site consists of several buildings:

- Building A - a historic building from the 1920s,
- Building B - a new building built in 2014,
- Building C - a building from the 1960s,
- Building D - a building from 2006,
- Building K - a newly constructed Cryomicroscopy building,
- Other buildings - garage stacker system, entrance building, warehouses, nitrogen farm.

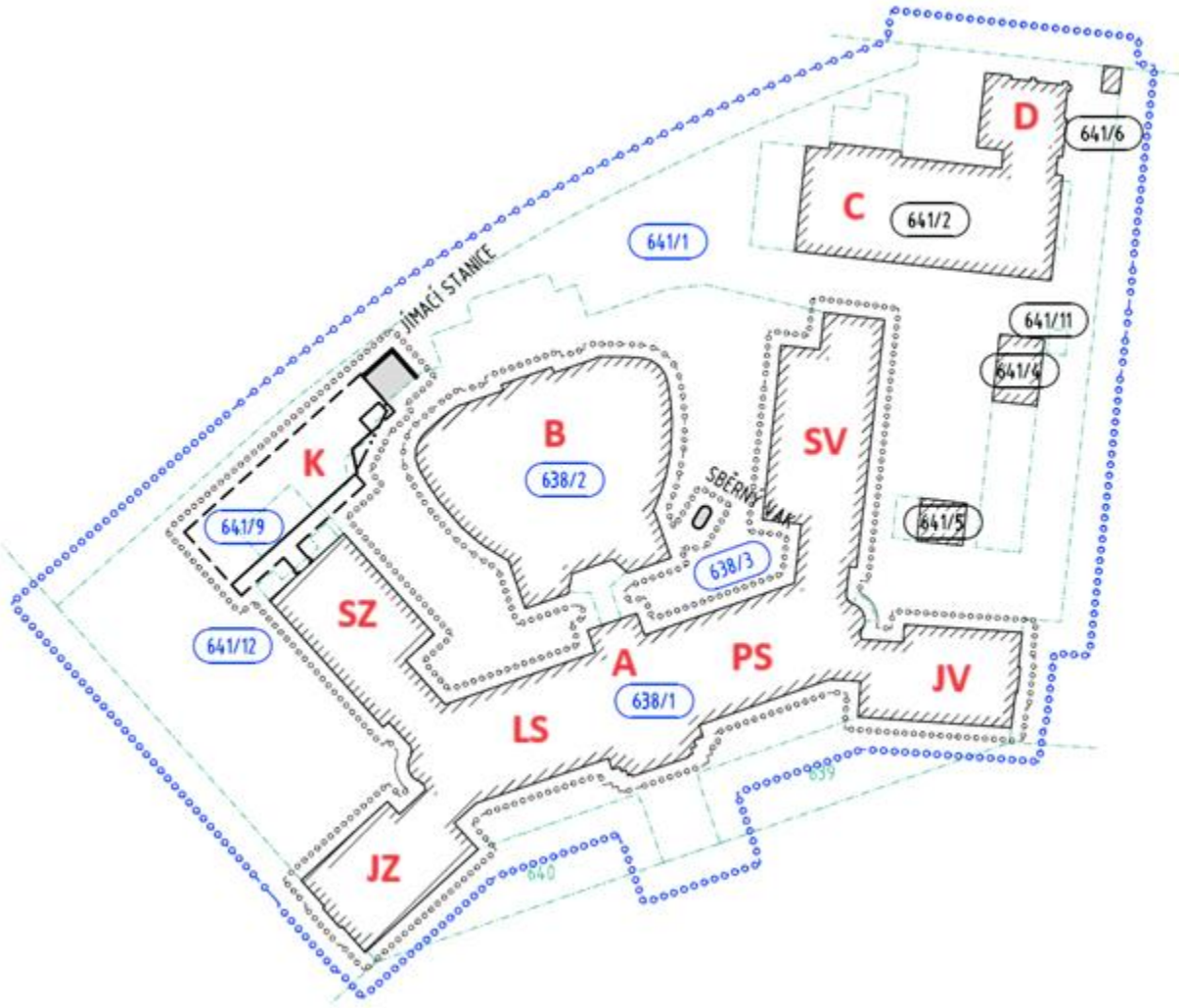


Figure 1: The building situation of IOCB (source: Karel Šobíšek, APRIS 3MP, s.r.o.)

The sources of helium gas are the NMR group, which is located in the NE wing of Building A and the newly acquired SPM, which will be located in Building K. This means that the sources will be located on opposite sides of the campus. This brings the problems of the low-pressure pipework, the location of the collection bag and the location of compressor. The ideal location for the collection bag is indoors where it will not be exposed to the weather, unfortunately there is no such space that is large enough and easy to connect to the piping system. The collection bag can also be located outdoors, but this brings several complications that increase the initial acquisition costs. It must be covered - preventing water access and subsequent freezing. If the bag were empty, the top recess would be rained into, and the water would subsequently freeze. The pressure of the evaporated gas would not be sufficient to displace the ice and the capacity of the bag would be severely limited, leading to increased operating costs. Another problem is that the freezes could mechanically damage the bag during inflation. For this reason, the bag must be roofed with the need to apply for a building permit and associated zoning changes.

The location of the bag was chosen between the NE wing and the Right Centre of Building A and Building B. The collecting pipe (marked in yellow) from the NMR in the NE wing of Building A and from the SPM in Building K runs in the 2nd basement of Building A to Building B and is connected to the collection bag - marked with a yellow square. Subsequently, the gas is pumped out by the compressor through the pipeline in the same route - marked in green. The compressor will be located on the 2nd underground floor of Building K, in the interior heated spaces - exterior

location is not possible. A short high-pressure section will then lead to the exterior of Building K. This location is easily accessible by truck and handling equipment.

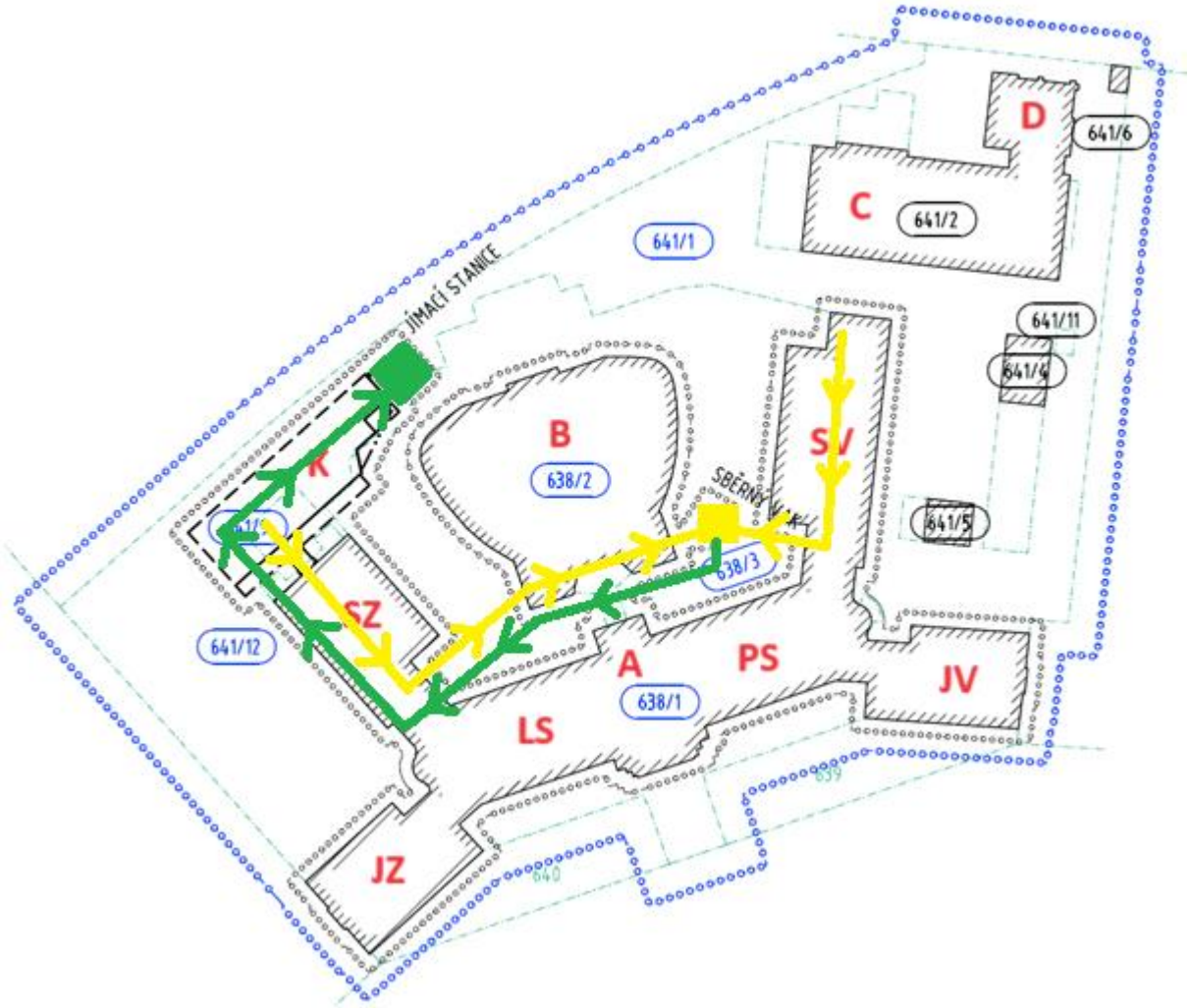


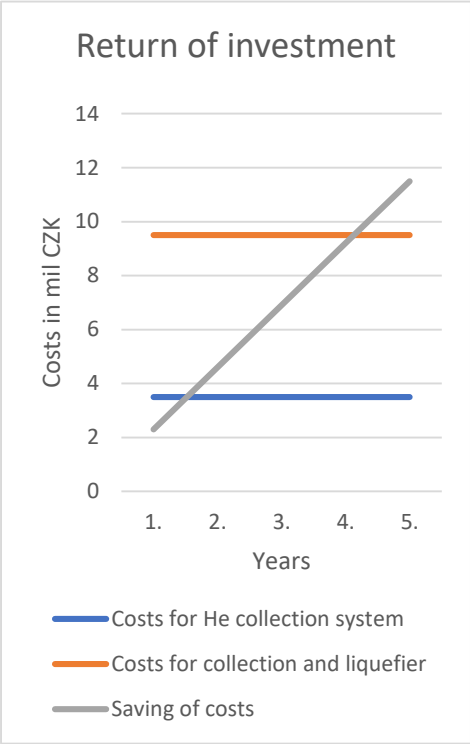
Figure 2: The building situation of IOCB with pipelines (source: Karel Šobíšek, APRIS 3MP, s.r.o.)

Return on construction investments

Available literature and manufacturers´ report that the efficiency of He liquefaction is around 70%. The initial costing of the helium recovery system at IOCB is 3.5 million CZK, without VAT. When including the operating costs for transporting the bundles of cylinders to the liquefier and bringing the liquid helium back, we estimate an efficiency of 60%.

The annual cost of purchasing liquid helium at volumes of 6000 litres is 5.8 million CZK at today's prices per litre of helium. This means an annual saving of 2.3 million CZK. This implies that the return on investment for the construction of the helium storage section is 18 months. The return for the share in the pooled investment for the acquisition of the liquefier (6 million CZK) is 31 months. The total return period is 49 months - 4 years. After four years, the supply of helium to the above facilities would represent a cost (at 2023 prices) of about 2 million CZK, a saving of two thirds of the current cost.

Graph 1: The Price of liquid helium (source: Karel Šobíšek)



Conclusion

The graph above shows that the planned investment in the helium gas capture and re-liquefaction system is highly efficient. If liquid helium prices increase at the same rate, the return on this investment will be even faster.

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16. Opinions About BIM, LCA and LCC in Czech Construction Industry

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Abstract

This paper is focused on getting data of awareness and opinion about Building Information Modelling (BIM), Life Cycle Assessment (LCA), and Life Cycle Cost (LCC). Data are from three groups, all of whom are construction related white-collar workers from: Public sector, Private sector, and Academia. Data show comparable results between Academia and Private sector. Public sector fell behind in most areas, apart from interest and opinion of Life Cycle Cost. In total 143 respondents answered 19 questions each.

Keywords

BIM; LCA; LCC; Survey; Questionnaire survey

Introduction

The BIM (Building Information Management) is a method of working with all information about a built object, during its whole life cycle, in digital form. Emphasis is on the digital form of information because only the digital form of information enables fully automatic or at least semi-automatic data processing. Automatic form of processing means that computers can process data without time intensive interpretation by a human. Computers are capable of that no matter of size or complexity of data, usually in a fraction of the second [1].

The LCA (Life Cycle Assessment) is a quantitative tool to assess the impact of a built object from an environmental point of view. LCA is also included all the resources it and its usage will consume (electricity, heat, water, etc.), and resources needed for its demolition and recycling/disposal of all its material at the end of its life cycle [2]. The crucial part of the LCA is the assessment is performed for the whole life cycle of the built object. It discourages to only move "the problem" from one phase to another [3]. For example, it is possible to save some materials in the Construction phase (insulation, material quantity/quality, etc.) but in the Use phase it will mean the need for more heat, higher maintenance, etc. LCA is in general about choosing the correct structural system/material and finding the balance between investment upfront and during use.

The LCC (Life Cycle Cost) method assesses the cost of the built object during the whole life cycle of the building. The usual method is to evaluate only the cost of construction, but not to take into account maintenance, repairs, and eventual demolition/reconstruction. The cost connected to the Use phase are major part of the whole amount [4]. Some sources cite up to 5x higher cost during the Use phase in comparison to the construction phase.

All above mentioned topics are connected. The connection is through the data because LCA and LCC are methods that use the data to assess the built object and BIM model – the backbone of BIM, contains all the information (data) needed.

The question is, how is the Czech construction sector perceiving all the above mentioned? If people are interested in BIM, LCA, and LCC? If they have some experience using the methods, which are relatively new and still not a standard on every project? To try to answer these questions of the goal of this paper.

Methodology

The survey was designed to get data about the awareness and opinion of construction related white-collar workers about BIM, LCA, LCC, and its connection. More specifically the target group was people with a strong connection to the construction industry or directly working in the construction industry, who could decide about the use of BIM, LCA, and LCC in construction projects in the Czech Republic.

The respondents were contacted directly by the author using email or other form of direct communication or through a third person to access as many respondents as possible. Most of the respondents were in Prague or The Central Bohemian region with construction projects from all over the Czech Republic. In general, the targeted groups were:

- Public sector – representatives of municipalities
- Private sector – construction projects team members of investors or general contractors for large construction projects (in general 100 mil CZK and more)
- Academicians/Researchers – from Czech civil engineering faculties with connection to at least one of the areas of interest

Furthermore, the groups of Public and Private sectors were divided into management and non-management positions.

The survey contained 19 questions divided into four sections. The number of questions was intentionally kept under 20 to not discourage the respondents from participating because there were no material incentives connected. All questions were option based and can be seen below:

- General
  - **Q1: In which sector do you work?**
    - Answers: Academic / Private sector – management / Private sector – non-management / Public sector – management / Public sector – non-management
- BIM - BIM - Building Information Management
  - **Q2: Did hear about BIM - Building Information Management?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q3: Did you work on project which used BIM?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q4: Did you work in BIM or know how to work in BIM?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
- LCA – Life Cycle Analysis
  - **Q5: Were you ever interested in CO2 emissions of a building and tried to lower it?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q6: Did hear about LCA – Life Cycle Analysis?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q7: Did you work on a project where LCA was performed?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q8: Did you perform LCA or know how LCA is performed?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q9: Do you see the benefit in performing LCA?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q10: Do you think that in the future LCA will be performed more often?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q11: Which LCA certification do you know (pick one or more options)?**
    - Answers: LEED / BREEAM / SBToolCZ / Levels(s) / Other
  - **Q12: Do you see benefits in connecting BIM and LCA?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
- LCC – Life Cycle Cost
  - **Q13: Were you ever interested in cost of a building during its whole life cycle and tried to lower it?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q14: Did hear about LCC – Life Cycle Cost?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q15: Did you work on a project where LCC was performed?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q16: Did you perform LCC or know how LCC is performed?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q17: Do you see the benefit in performing LCC?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q18: Do you think that in the future LCC will be performed more often?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know
  - **Q19: Do you see benefits in connecting BIM and LCC?**
    - Answers: YES / Mostly YES / Mostly NO / NO / I don't know

The survey was conducted using Microsoft Forms with a license provided by Czech Technical University in Prague - Faculty of Civil Engineering. And distributed to respondents using the https hyperlink address. The answers were

anonymously recorded by the system and in the end managed in Microsoft Excel. The survey was conducted during the fall of 2023.

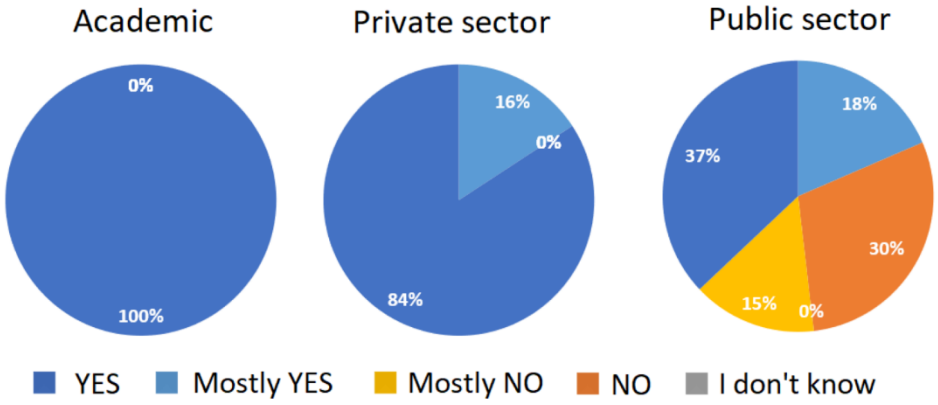
Results

In total there were 143 participants in the survey see Table 3.

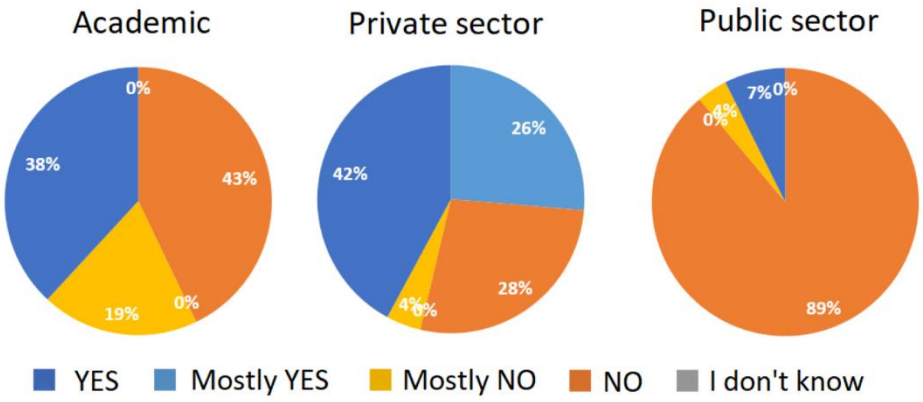
Academic	21
Private sector - non-management	55
Private sector - management	40
Public sector - non-management	18
Public sector - management	9
Total	143

Table 3. Number of participants based on the groups

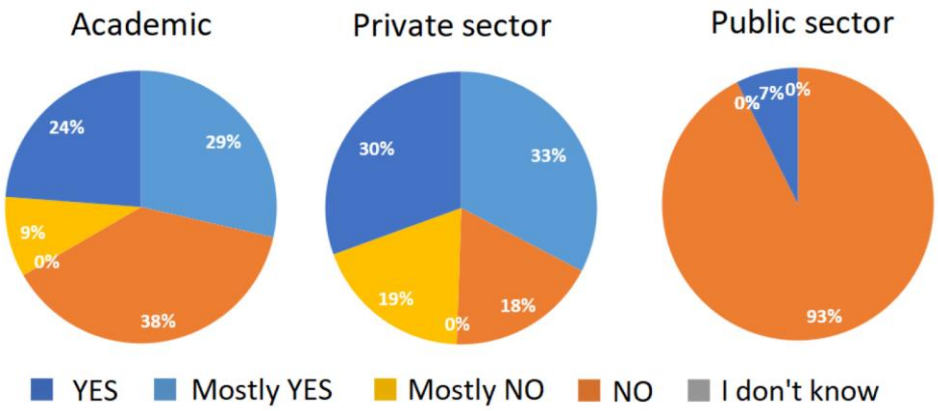
Q2: **Did hear about BIM - Building Information Management?**



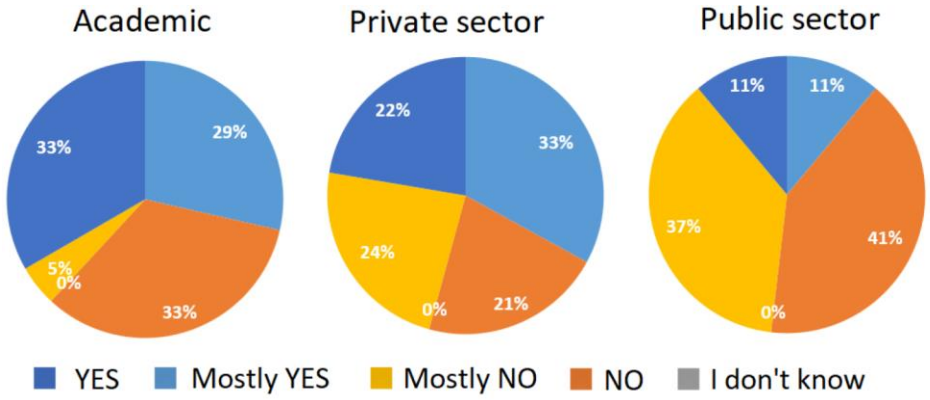
Q3: **Did you work on project which used BIM?**



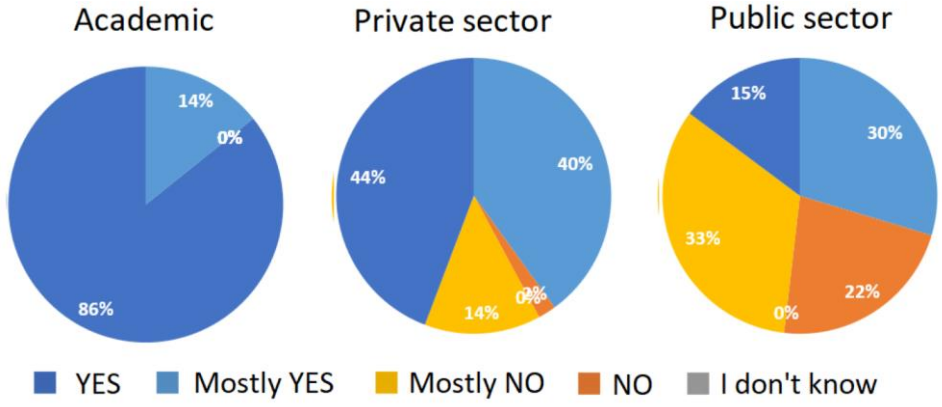
Q4: **Did you work in BIM or know how to work in BIM?**



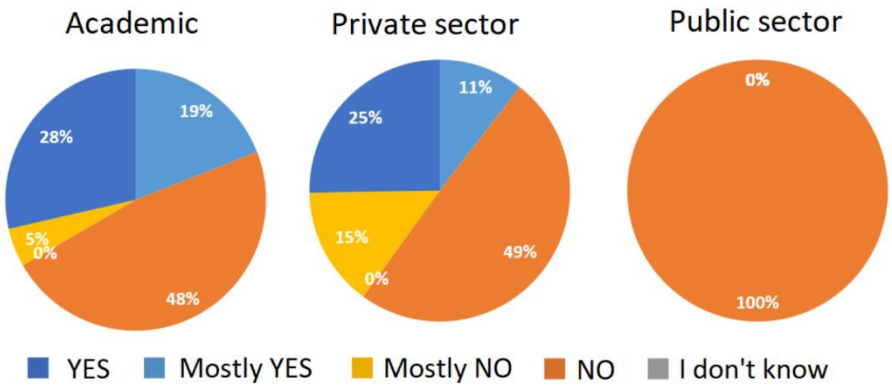
Q5: **Were you ever interested in CO2 emissions of a building and tried to lower it?**



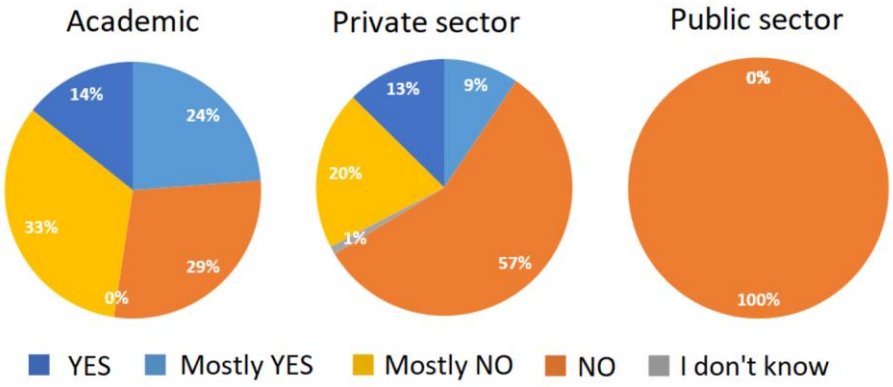
Q6: **Did hear about LCA – Life Cycle Analysis?**



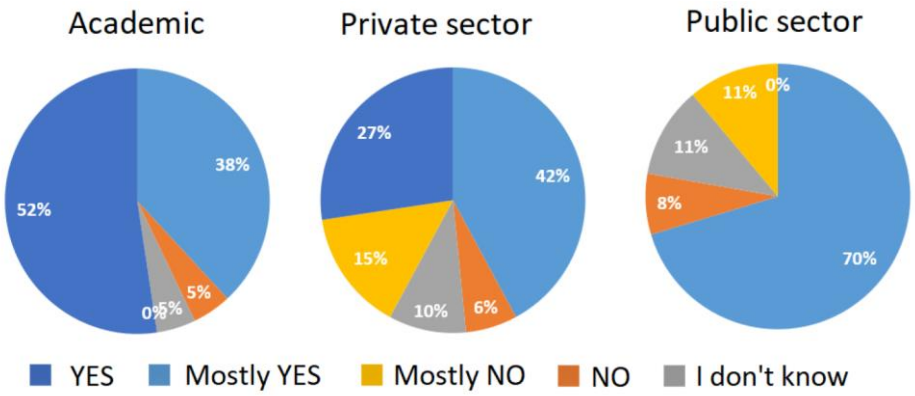
Q7: **Did you work on a project where LCA was performed?**



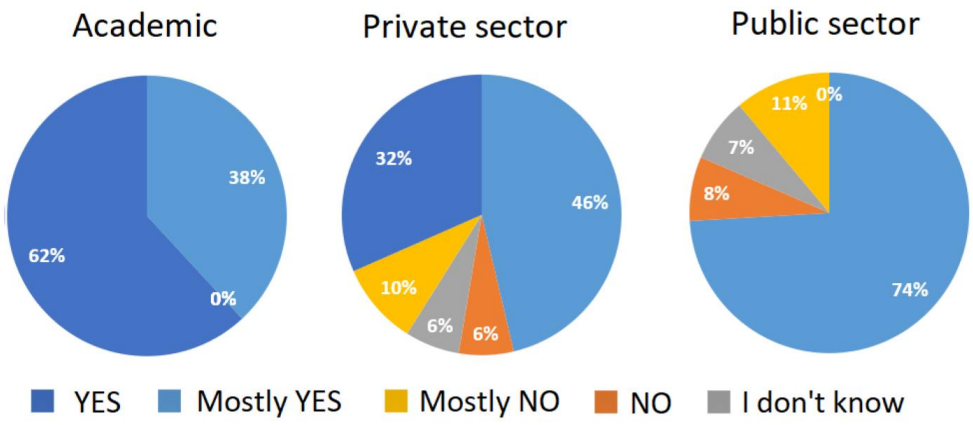
Q8: **Did you perform LCA or know how LCA is performed?**



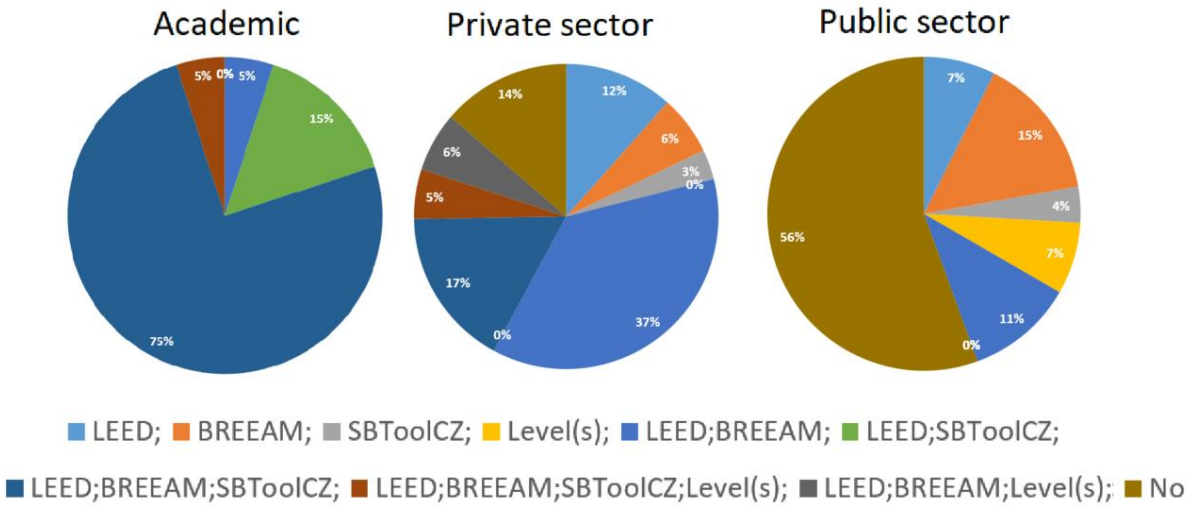
Q9: **Do you see the benefit in performing LCA?**



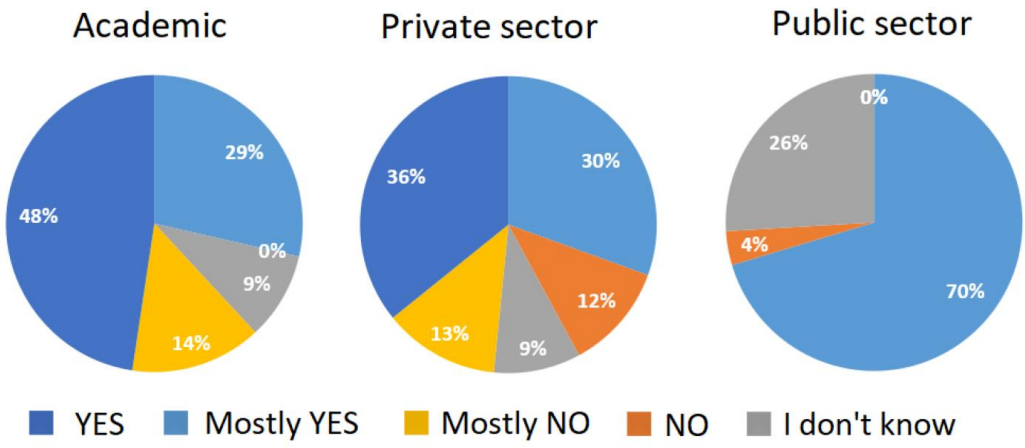
Q10: **Do you think that in the future LCA will be performed more often?**



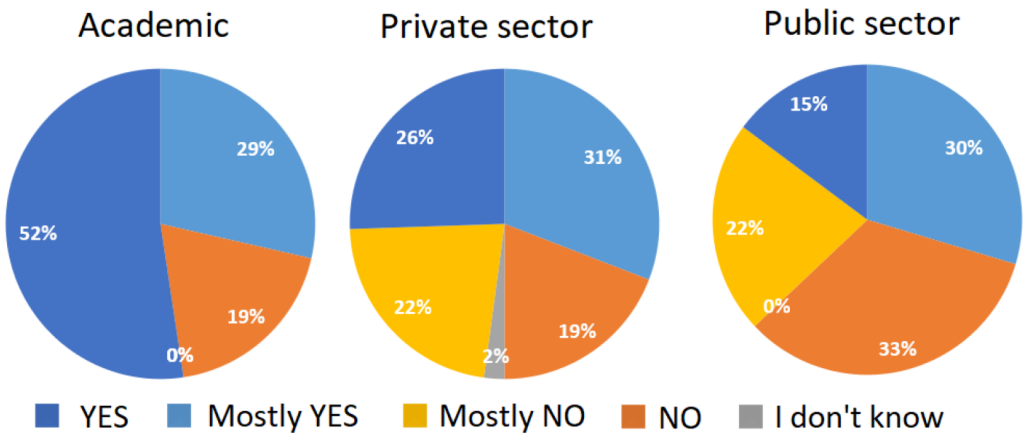
Q11: **Which LCA certification do you know (pick one or more options)?**



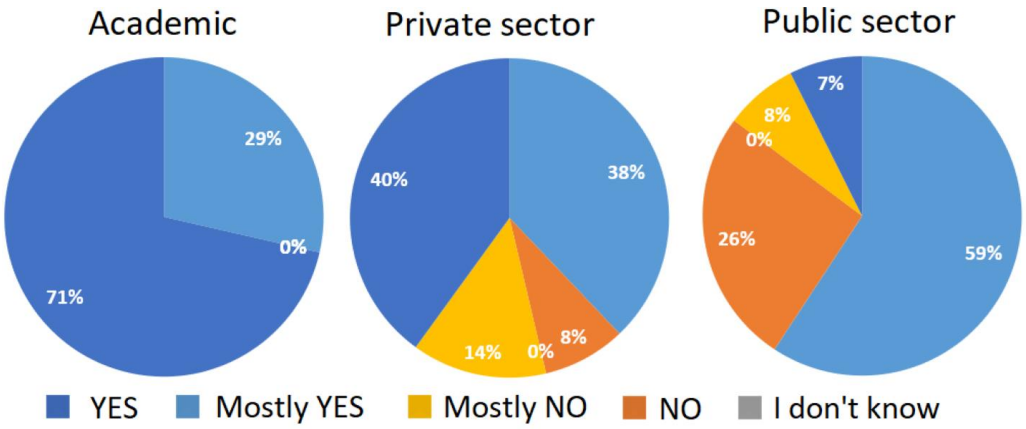
Q12: **Do you see benefits in connecting BIM and LCA?**



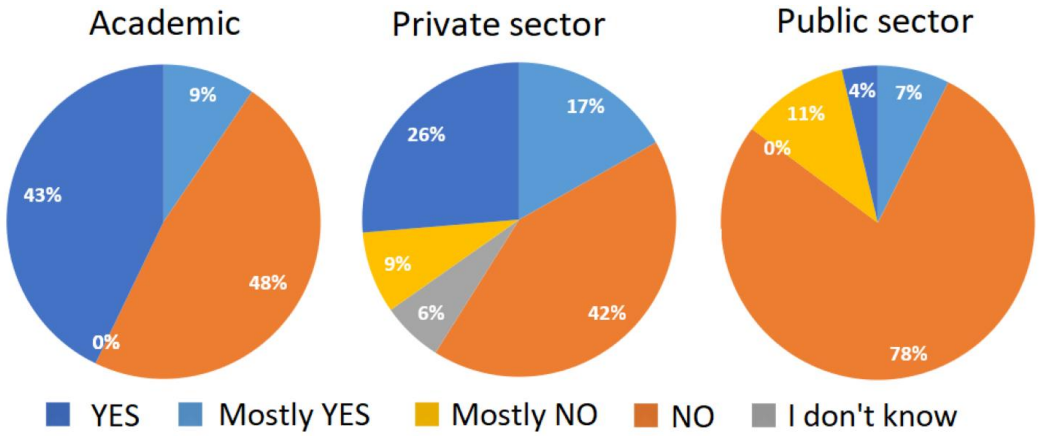
Q13: **Were you ever interested in cost of building during its whole life cycle and tried to lower it?**



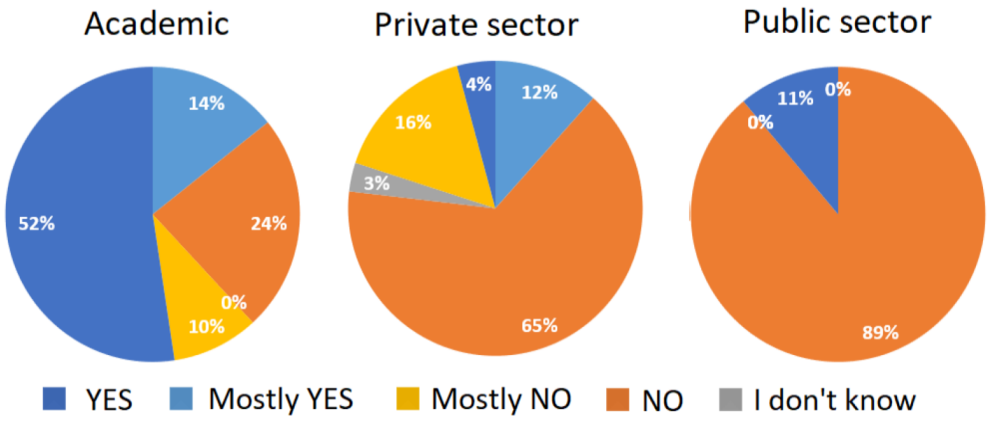
Q14: **Did hear about LCC – Life Cycle Cost?**



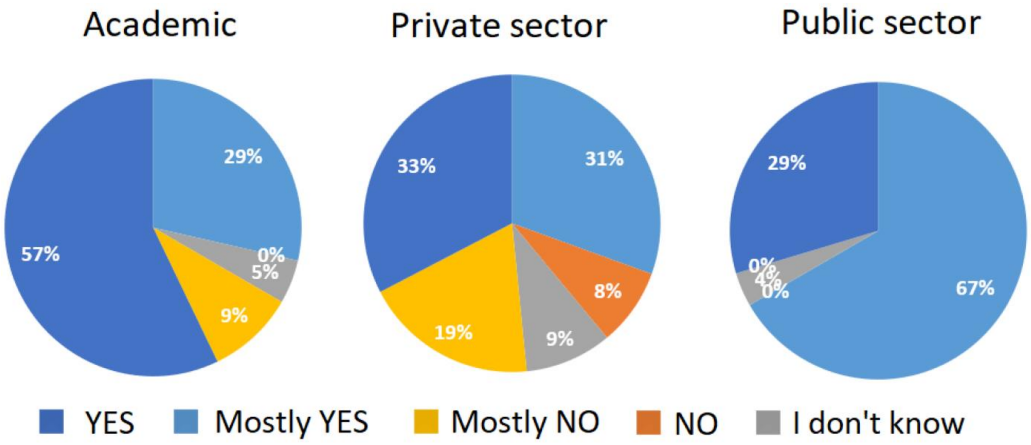
Q15: **Did you work on a project where LCC was performed?**



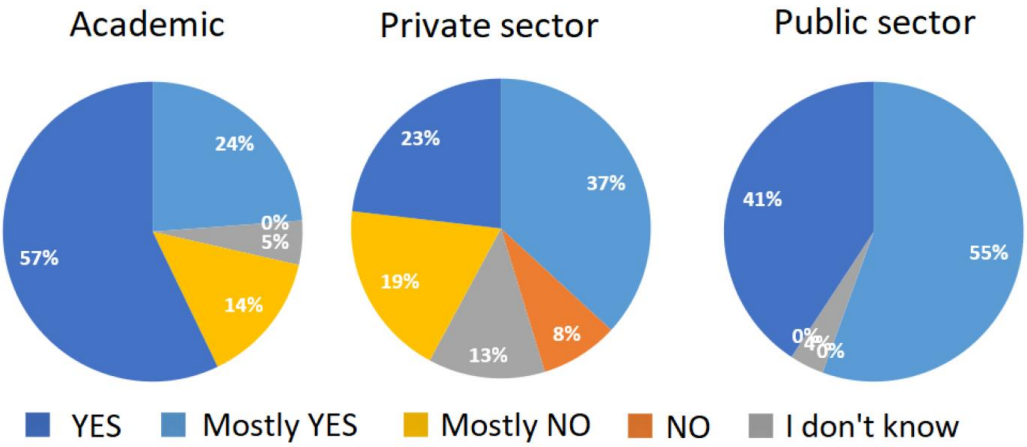
Q16: **Did you perform LCC or know how LCC is performed?**



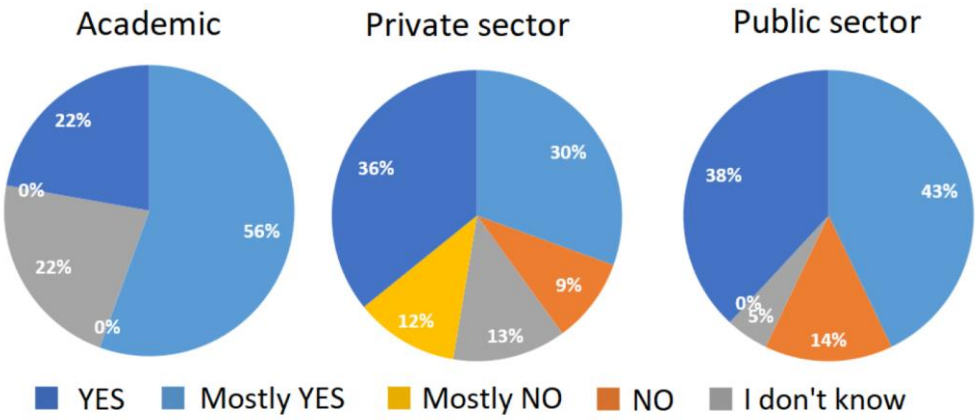
Q17: **Do you see the benefit in performing LCC?**



Q18: **Do you think that in the future LCC will be performed more often?**



Q19: **Do you see benefits in connecting BIM and LCC?**



For raw version you can write to vojtech.stary@fsv.cvut.cz.

Conclusion and discussion

The results can be seen above, they show that trends are group dependent. In general, respondents from Academics were the most aware of the topics and had the most experience. Respondents from the Private sector are close behind the Academics in most topics with mostly positive opinion and knowledge. Respondents from the Public sector have in most of the topics less awareness and experience. One exception is opinions about LCC and its use, where they see it as more beneficial and more likely to be used more often in the future. It is according to the authors opinion due to the focus on the price of the construction project usually as the only criteria for choosing the general contractor in public tenders.

Questions 5 and 13 were worded specifically without using abbreviations and in general resulted in higher agreement than other comparable questions. It shows that the abbreviations in the construction industry, mainly the new ones can scare people off and prevent spreading new tools and processes to help build a better environment.

Possible problems with the survey could be: a relatively low number of respondents from the Academic and Public sectors, which are caused by a lower absolute number of people working in the sector (because the time spend sending the survey out to respondents was approximately the same for all three groups), compared to the Private sector, lower motivation to fill in the survey. The lower number of respondents also can mean possible bias based on respondents' expertise and local environment.

Acknowledgement

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17. Tendering Using Application for E-Procurement of Subcontractors

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Abstract

This paper is a continuation of author's previous publication, where the development of an e-procurement application for tendering subcontractors using low-code platform Xeelo was presented. The introduction section briefly describes previous development of e-procurement application and the low-code technology. It also describes the newly developed objects, functionalities, and interconnection of the e-procurement application. Results of the paper were obtained by following methods: configuration and programming of an application using low-code platform called Xeelo. Requirements for configuration and programming were obtained by conducting interviews with construction procurement specialists, analysis of current procurement processes of subcontractors, author's innovation, modelling of procurement processes and modelling of UML diagrams. New features and objects in relation to previously developed objects are presented in the result section. Two new objects were developed to the e-procurement application. The first newly developed object is Inquiry template, which serves as a database of inquiry templates that can be used to generate tailored inquiries to subcontractors. This object is interconnected to the already developed object Tenders, where inquiries to subcontractors are loaded and tailored for the tender. The second newly developed object is Bids, where subcontractors can submit their bids based on the received inquiry. This object is also interconnected with the object Tenders as bids are generated from object Tenders. Two scenarios of submitting bids are taken into consideration. The first scenario is when subcontractor's employees are users of e-procurement application and can hence submit their bid directly in the application. The second scenario is when subcontractor's employees are not users of e-procurement application. That is why, they will submit their bids by e-mail or by external link, without the need of logging into the e-procurement application. Conclusion and discussion section summarizes the already developed functionalities of e-procurement application, states the importance of this research, and outlines further development of the e-procurement application.

Keywords

construction; digital transformation; low-code development; process management; procurement

Introduction details

Aim of this paper is to describe the new development, which followed the previous development of the e-procurement application. It is a direct continuation of author's previous publications [1]–[7].

The paper is focused on the new development of e-procurement application that was developed by the author. Previous development is briefly described to provide a bigger picture of the e-procurement application. That is why, two object types, Master data and Procurement are summarized. Objects categorized into these two object types are listed. These are namely following objects Subcontractor, Department, Work package, Type of construction, Personal tender template, Type of construction tender template, Department tender template, Projects, Tenders. Each object's purpose, functionality and interconnection with other objects is presented. The central point of the paper is however the newly developed objects. These objects are Inquiry template and Bids. Object Inquiry template is categorized under the Master data object type, as its purpose is a to manage wording of inquiries. Inquiry templates can be assigned to multiple departments that will later be able to use them in the object Tenders to generate a tailored inquiry wording of a particular work package for tendering subcontractors. To do so, placeholders are used in the inquiry templates, that will be replaced by real tender data once loaded into a tender. Object Bids is categorized under the Procurement object type, as its purpose is to provide subcontractors with the possibility to submit their bids and for quantity surveyors to evaluate them. Bids can generally by created in two ways. The first way is to generate bids from object Tenders. That is why the process of bids creation from object Tenders is also described. The second way is to create bids using external link that is provided in the inquiry text. The first way is meant for subcontractors whose employees have access to the e-procurement application and can hence work in it. The second way is meant for subcontractors whose employees do not have access to the e-procurement application. That is why, both types of subcontractors can submit their bids into the e-procurement application. The differences between these two types of bids submission are described including the difference in their workflows in the e-procurement application. This paper is dealing with the problem of lack of digital applications that would comprehensively support the procurement processes of subcontractor in the construction sector.

Methodology details

Methods used for obtaining results are following in respect order:

- semi structured qualitative interviews with construction procurement specialists,
- analysis of current procurement processes of subcontractors,
- modeling process maps representing the procurement processes of subcontractors,
- analysis of current digital platform's functions supporting procurement processes,
- research of UML diagrams,
- modeling of UML diagrams,
- author's innovation of functions that can support procurement processes,
- configuration and programming e-procurement application using low-code development platform Xeelo.

Conducted interviews provided an insight into the management of current procurement processes of subcontractors. Information gather from these interviews were analyzed, which provided a background for process maps of current procurement processes of subcontractors. The author modeled these processes into process maps. Later analysis of current digital platform's functions that do support procurement processes was performed to evaluate whether these functions satisfy the current needs of construction procurement specialists. The outcome of the analysis detected functions that the analyzed digital platforms were lacking. Research and modeling of UML diagrams summarized the actors participating in the procurement processes, their needs, and their use cases. The author synthesized all gather information and used his innovation to propose new functions that will support

procurement processes of subcontractors. At last, the author used his knowledge of low-code platform Xeelo to implement these functions into a newly developed e-procurement application.

Results details

The result section will first briefly describe the previously developed objects, to provide a broader picture of the e-procurement application. Then newly developed objects, their purpose, key functionalities, and interconnection with other object will be presented in detail.

Previously developed objects

Previously developed objects are divided into two object types. The first object type is Master data that servers as a basis for the objects in the second object type that is Procurement. So, to speak, Master data are basically a list of data that are later used in the transaction data that are covered in the Procurement object type.

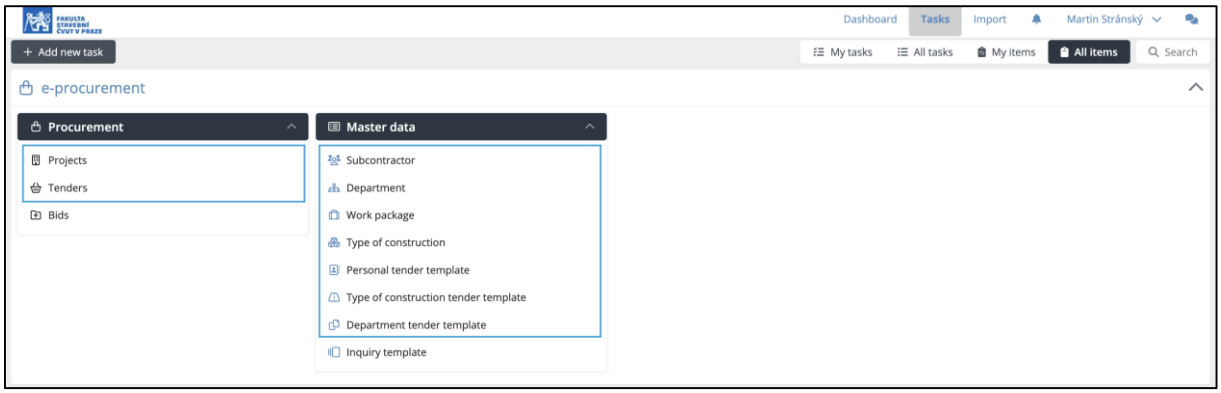

Figure 3. Highlighted previously developed objects

- Master data – object type
  - Subcontractor
  - Department
  - Work package
  - Type of construction
  - Personal tender template
  - Type of construction tender template
  - Department tender template
- Procurement – object type
  - Projects
  - Tenders

Subcontractor

Purpose of this object is to manage a database of subcontractors, including their basic information with the list of work packages that they can perform. Functionality of this object is integration with Czech business register to fill in subcontractors' general business information. This object is interconnected with other objects in a way that it provides a list of subcontractors that can be inquired for a given work package.

Department

Purpose of this object is to administer database of contractor's departments and their respective workers. Functionality of this object is to generate an OrgChart that will be assigned to other objects to guarantee that department's workers are able to see only data that are relevant to their department. This object is interconnected to other objects that it is possible to select given department responsible for a request in the given object.

Work packages

Purpose of this object is to manage database of work packages that are fundamentally a classification system of works, materials and other construction assets that are to be delivered to contractor's projects. Functionality of this object is that work packages can be sorted into a parent and a child hierarchy. That means that a specific work package can have one parent work package and multiple child work packages. Other functionalities are standard data for procurement, and overview of subcontractors that can provide the specific work package. This object is interconnected with other objects in a way that it provides a list of work packages that can be inquired by the contractor.

Type of construction

Purpose of this object is to manage types of construction that the contractor usually constructs. This object is interconnected to further objects in form of a list of types of construction from which users can choose.

Tender templates

There are three types of tender templates: Personal, Type of construction, and Department tender template. Purpose of these objects is to manage a tender template for further processing in object Tenders. Users can specify the combination of work packages and subcontractors that they would like to usually inquiry without the need of manually selecting them into the tender. All these objects are interconnected specifically with objects Projects, and Tenders. They serve as template from which combination of work packages and subcontractors can be loaded into a specific project and/or specific tender.

Projects

Purpose of this object is to manage, process and approve projects that the contractor would like to construct. It contains project's general information, each project is assigned to a specific department that is responsible for the project, it also contains contractor's team involved in the project, and most importantly initial tender plan. Functionalities of this object are to approve new projects that shall be constructed, as well as load data from Master data objects, such as load work packages and subcontractors from tender templates, and to generate tenders of subcontractors. This object is interconnected with multiple objects, specifically with Tender templates, Tenders, Department, Subcontractors, and others.

Tenders

Purpose of this object is to process tenders of subcontractors. It contains all required information regarding the inquiry of subcontractors. Such as, which work package is being tendered, for which project, which quantity surveyor is responsible for the tender, important milestones, related documentation, and most importantly, which subcontractors will be inquired in the tender. Functionalities of this object is to load bidders for a given work package that is being tendered, and to send inquiries to subcontractors and to create empty bids for subcontractors, who have access to the e-procurement application. This object is interconnected predominantly with following objects: Tender templates, Inquiry template, Subcontractor, Projects, and Bids.

Newly developed objects

Two newly developed objects are Inquiry template categorized in the object type Master data, and Bids categorized in the object type Procurement. These two objects will be described in detail, mainly their purpose, key functionalities, and interconnection with other objects.

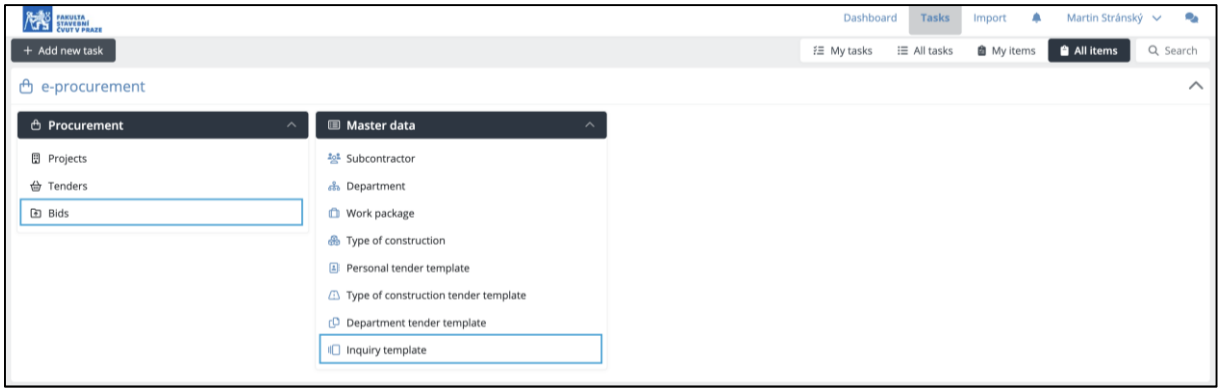

Figure 4. Highlighted newly developed objects

Inquiry template

Purpose of this object is to manage wording of inquiry templates in a centralized place, from where they can be used in other objects within the e-procurement application, and if necessary, by means of integration in third party business applications. There is no restriction on how many inquiry templates there can be in the application, hence each user with appropriate user permission can create an inquiry template that he can then later use to generate real inquiries of subcontractors. Each inquiry template can be assigned to multiple contractor's departments. Contractor's users will then be able to load specific inquiry templates into tenders of specific projects for which appropriate department is responsible.

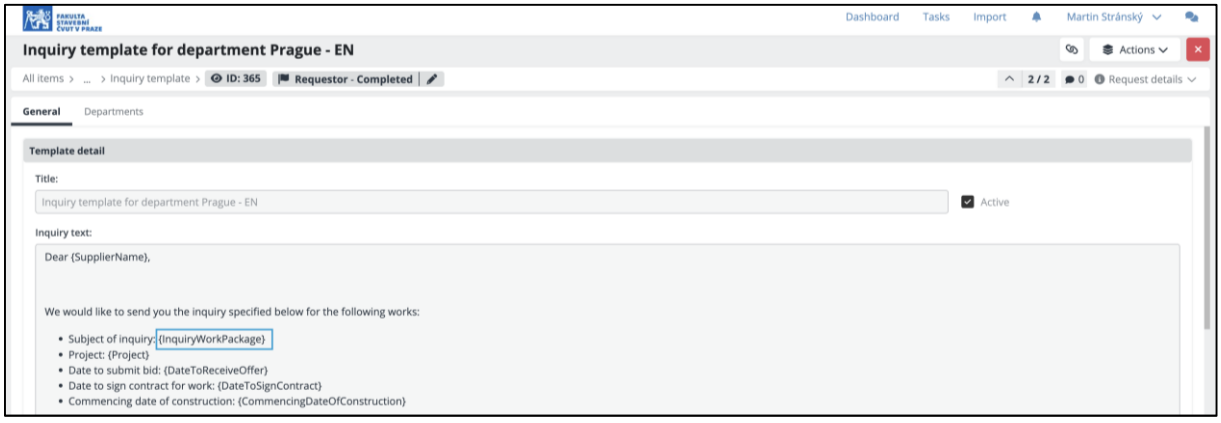

Figure 5. Inquiry template wording with highlighted placeholder

Functionalities of this object are to provide a title, define whether it is active or not for further use, list departments that will be able to utilize given inquiry template, and most importantly fill in the inquiry wording using text and placeholders. A list of available placeholders is listed in each inquiry template for the users to know, which placeholders they are allowed to use. Used placeholders will be later replaced by real data in object Tenders.

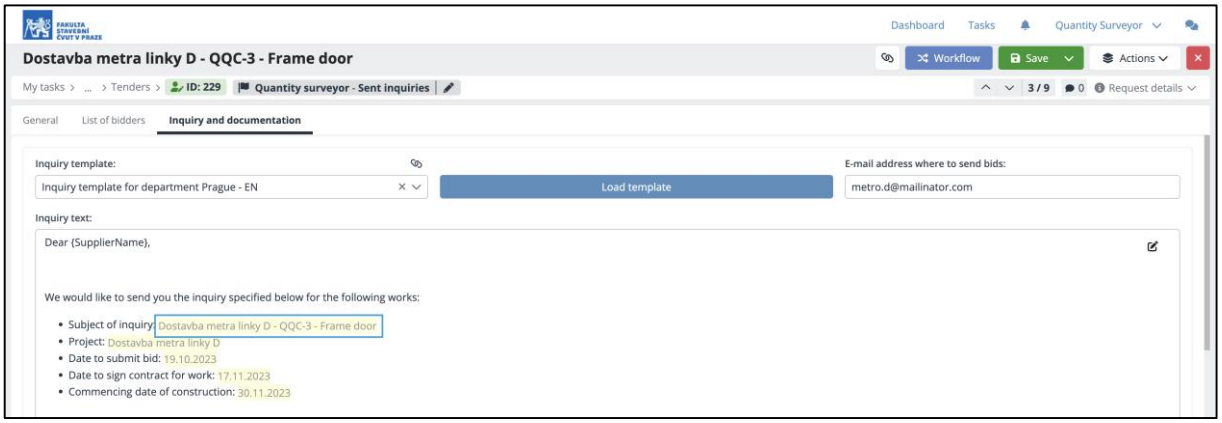

Figure 6. Inquiry template it tender with highlighted real tender data that replaced placeholders

This object is interconnected with object Tenders. Object Tenders was enhanced with a possibility to select an inquiry template available to the responsible department of a tender and to load inquiry wording from selected inquiry template by a provided button. When a button is pressed, then inquiry wording from a selected template will be loaded into a provided field in the tender. Placeholders defined in the inquiry template will be replaced by real data in the given tender. For example, placeholder {InquiryWorkPackage} will be replaced by the title of a work package that is being tendered, etc. Responsible quantity surveyor can then edit the loaded inquiry wording and retype it into a final form that will be sent to the selected subcontractors in the tender.

Bids

Purpose of this object is to provide subcontractors a mean of how to submit their bids after receiving an inquiry for a respective tender. Bids can be created in two ways. The first way is to generate them from a tender, which can be done by a responsible quantity surveyor. This way is designated to subcontractors that have user access to the e-procurement application. The second way is to create a bid using an external link, which is used by subcontractors that don't have user access to the e-procurement application. Both ways are described in detail below, but before that, process of preparing inquiries in object Tenders will be presented.

Preparing inquiries in tender

When a tender is created a responsible quantity surveyor is defined. The responsible quantity surveyor must fill in tender general information such as, which work package and for which project it is being tendered, responsible department is then filled in by the system based on the selected project. Also planned time schedule of the tender can be filled in.

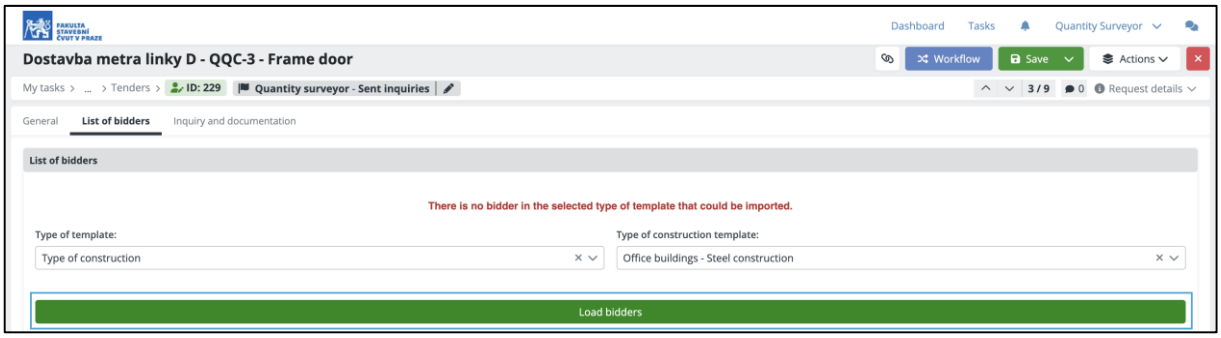

Figure 7. Button to load bidders from selected tender template into tender

After general tender information are filled in, then shall the responsible quantity surveyor define which subcontractors shall be inquired for a given tender. Quantity surveyor can utilize an available functionality to load bidders from tender templates defined in object type Master data. There are generally four types of tender templates.

- Subcontractor favorite
  - Subcontractors will be loaded from object Subcontractors if a respective work package that is being tendered is defined as their favorite.
- Personal
  - Subcontractors will be loaded from object Personal tender template that was created by the responsible quantity surveyor of a given tender.
- Type of construction
  - Subcontractors will be loaded from object Type of construction tender template. Responsible quantity surveyor can select a specific tender template from which subcontractors will be loaded.
- Department

- Subcontractors will be loaded from object Department tender template. Responsible quantity surveyor can select a specific tender template from which subcontractors will be loaded.

Subcontractors will be loaded from any template only in case they are specified for a given work package that is being tendered. That is why, in case no subcontractors can be loaded into the tender, then the responsible quantity surveyor is presented with a message that no subcontractors could be loaded.

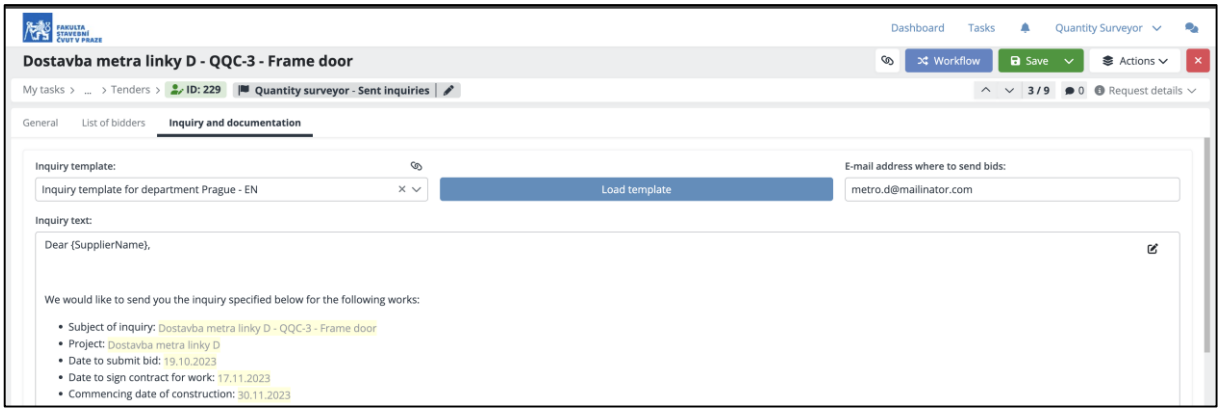

Figure 8. Tender with highlighted replaced placeholders by real tender data

After a list of subcontractors that will be inquired in a tender are defined, then responsible quantity surveyor can fill in tender documentation URLs and upload important files. At last, can he utilize newly developed functionality mentioned in the previous chapter. That is to select an inquiry template and load its wording into a given tender. As mentioned in the previous chapter placeholders defined in the inquiry template wording will be replaced by real data in the given tender. That is why, when the responsible quantity surveyor presses provided button to load inquiry wording from selected inquiry template the inquiry text will be tailored for a given tender. To make it easier for the quantity surveyor to recognize, which tender data replaced placeholders in the inquiry wording, the real tender data will be highlighted in yellow color. To tailor the inquiry as much as possible to a given tender and possibly to each subcontractor, is the quantity surveyor able to edit the loaded inquiry wording.

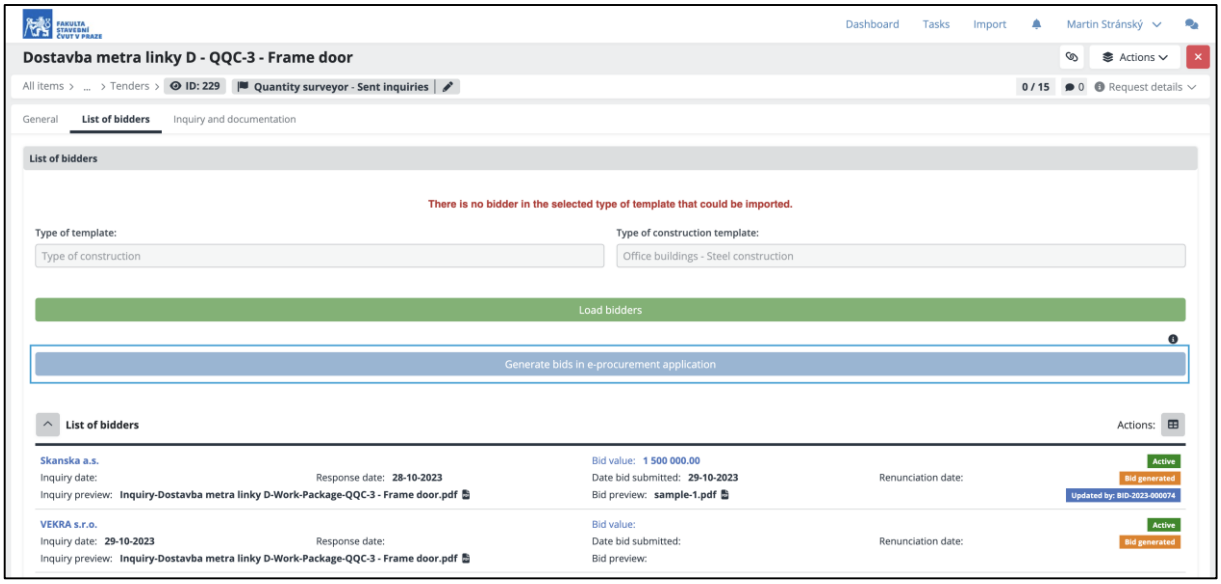

Figure 9. List of bidders with highlighted button to generate bids in e-procurement application

When all subcontractors are selected in the tender and inquiry text is finalized, then can the quantity surveyor send inquiries to the subcontractors. Quantity surveyor can define if a bid will be generated for specific subcontractors in the e-procurement application. Bids for subcontractors can be generated only in case subcontractor has some active users of e-procurement application. Otherwise, it won't be possible to generate a

bid for the subcontractor in this way. Subcontractors that do not have access to the e-procurement application, or they do, but a bid for this tender won't be created for them, will receive an inquiry by e-mail that is specified in their profile in object Subcontractor.

Bid generated from a tender

Process of generating tenders for subcontracts was described in the previous subchapter, that is why this subchapter will describe the differences between bid generated for the subcontractor and the bid created by external link.

The major difference is that the bid is assigned to subcontractor's users in the e-procurement application with all inquired details. That is why, any subcontractor's user can view the inquired details. That is the work package that is being tender, for which project it is being tendered, who is the responsible quantity surveyor and most importantly the inquiry text, including a pdf file with the inquiry text. Then can any subcontractor's user submit file of a bid, including total bid amount, short and long description, and additional attachments. Once all the bid information is filled in, then can the subcontractor's user submit the bid for further processing. Subcontractors can renounce their participation in the tender. If they do so, this information will be transferred to respective tender in object Tenders with a date that the inquiry was renounced with a reason.

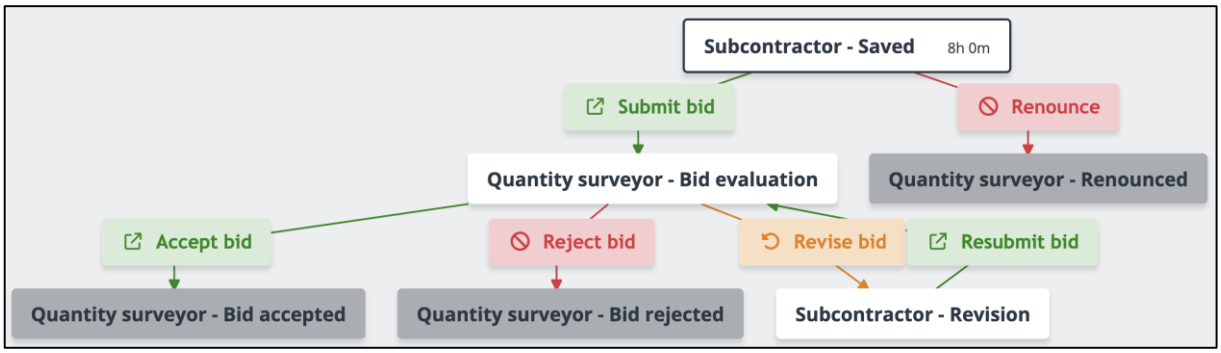

Figure 10. Bid workflow for bids created from object Tenders

Submitted bid will then be assigned to the responsible quantity surveyor, who can view and evaluate the filled in bid information. Later he can decide whether additional information is required from the subcontractor, or the bid is accepted, or rejected. If additional information is required, then the bid will be re-assigned to the subcontractor to add more information. If a bid is rejected, then a notification including e-mail will be sent to the subcontractor. If a bid is accepted, then a notification will be sent to the subcontractor and bid data will be transferred to corresponding tender in object Tenders with a date the bid was submitted, total amount without VAT, bid file, and bid description.

Bid created by external link

For those subcontractors, whose employees don't have access to the e-procurement application there is an option to submit their bids using an external link that is provided in the inquiry text. The link is provided only to those subcontractors that a bid wasn't generated in e-procurement application. This will ensure that only subcontractors that don't have access to the e-procurement application can create bids using external link.

These subcontractors will be provided with tender ID and their bidder ID that they shall fill in while creating a bid in the e-procurement application using the external link. This will allow the e-procurement application to identify to which tender and which subcontractor is submitting the bid. When tender and bidder ID is filled in, then shall the subcontractor upload bid file, and fill in total amount without VAT, and short and bid description. After all data are uploaded and all information is filled in, then can the subcontractor submit the bid into the e-procurement application.

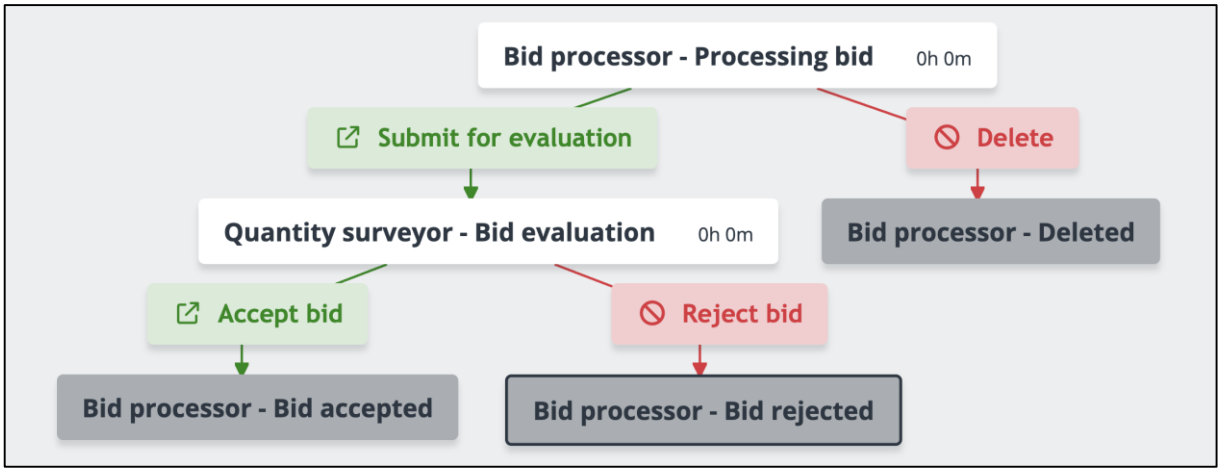

Figure 11. Bid workflow for bids created via external link

After bid is submitted by the subcontractor, it will be assigned either to bid processor, or the responsible quantity surveyor. In case subcontractor didn't fill in appropriate tender or bidder ID it will be first assigned to bid processor to identify, to which tender it belongs and which subcontractor has submitted the bid. Bid processor can decide whether to delete the bid if it is completely irrelevant or submit it for evaluation by the quantity surveyor. In case the subcontractor did fill in appropriate tender and bidder ID the bid will be sent directly to a responsible quantity surveyor for evaluation, and it will skip bid processor, as it is not necessary to identify the tender and subcontractor. Quantity surveyor has the possibility to accept or reject the bid. If a bid is rejected, then an e-mail notification will be sent onto subcontractor's general e-mail address. If a bid is accepted, then bid data will be transferred into corresponding tender in object Tenders and e-mail notification will be sent onto subcontractor's general e-mail address.

Conclusion and discussion details

Aim of this paper to describe new development in connection to the previous development of e-procurement application, and to follow up on author's previous publications was satisfied. New enhanced functionalities were developed to the e-procurement application as well as new development was interconnected with the previous development.

In the result section the previously developed objects were briefly described, and newly developed object were described in detail. Their purpose, functionality, and interconnection with other objects was presented. Previously developed objects are Subcontractor, Department, Work package, Type of construction, Personal tender template, Type of construction tender template, Department tender template, Projects, Tenders. The newly developed objects are Inquiry template and Bids. All objects are divided into two object types, that are Master data and Procurement. Master data are basically a database of data that are being used in transactional data that are covered in the Procurement object type. For example, object Subcontractor is a database of subcontractors, in the same way object Department is a database of contractor's departments. However, they are not just a database of static data, each object has its specific functionalities as well as workflow that allows various manipulation of data, and their approval. For example, each department defines the visibility of data in other objects, so workers of a given department can only see projects, tenders for which their department is responsible. Spotlight of the result section was laid on the newly developed objects.

The purpose of the object Inquiry template is to manage inquiry wording that can be later used for generating real inquiries of tenders. That is why, users with appropriate user permission can create and manage inquiry templates that generally consists of a title and inquiry wording with available placeholders. Later can a quantity surveyor load selected inquiry template wording into a real tender by utilizing a developed functionality. This functionality will not only load the inquiry wording from a selected template, but it will also replace provided placeholders by real data from a given tender. This will create a tailored inquiry to a given tender and a given

subcontractor. The quantity surveyor is then able to retype the loaded inquiry wording if further customization is required.

The purpose of the object Bids is to provide a way for subcontractors how to submit their bids into the e-procurement application. Generally, there are two ways how to submit bids into the e-procurement application. The first way is that a bid is generated for the subcontractor in the object Bids. This way is only available for those subcontractors whose employees have access to the e-procurement application and can hence work within in. The second way is that a bid is submitted by an external link that is provided only to those subcontractors whose employees do not have access to the e-procurement application, or a bid was not generated for them for a given tender. This way will enable the subcontractors to submit their bid without the need of login into the e-procurement application. At first the process of generating bids from object Tenders is described. Three major functionalities are presented here, those are, load subcontractors using tender templates, load inquiry wording and replace placeholders by real tender data using inquiry template and generate bids in e-procurement application into object Bids. At last, the differences between bid created from a tender and via external link are presented. Specifically, the differences between workflows.

In case bid was created from a tender, then subcontractor's employees can renounce to participate in the inquiry or submit their bid to the quantity surveyor for evaluation directly in the e-procurement application. The quantity surveyor then has the possibility to send the bid for subcontractor's revision, or reject it, or accept it. In case bid was created by external link, if the bid was not properly filled in, then it will be assigned to bid processor. Bid processor can either delete the bid completely or after filling in required fields submit it for quantity surveyor's evaluation. The quantity surveyor then has the possibility to accept or reject the bid. In this case the subcontractor is excluded from the workflow as his employees do not have access to the e-procurement application, they only receive e-mails.

The importance of this research is to provide contractors with a comprehensive solution for their procurement processes of subcontractors. Currently there are various solutions for generating inquiries based on templates as well as databases of subcontractors and departments, but there is no solution combining all the functionalities the developed e-procurement application can provide. That is what makes the developed e-procurement application stand out among the other solutions. The significant benefit of developed e-procurement application is available workflows behind each object and the possibility for subcontractors to submit their bids via the e-procurement application in case they have access to it, or they do not.

The further development of e-procurement application shall focus on submitting bids from subcontractors by e-mails, without the need of login into the e-procurement application or submitting it via external link. Then it shall focus on tender evaluation based on submitted bids by subcontractors leading towards the signature of a contract for work. That is why templates of contract for works shall be developed in a similar way as inquiry templates are already developed. Even more seamless user experience shall be supported by further interconnection of already developed objects within the e-procurement application with objects developed in the future. As it was already proven that developing the e-procurement application using low-code platform Xeelo is the right solution, the further development shall continue in this manner.

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18. the soaring role of drones in infrastructure inspection

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Abstract

The integration of unmanned aerial vehicles (UAVs), commonly known as drones, into the field of infrastructure inspection has marked a significant shift in how we manage and safeguard our critical infrastructure. This article explores the transformative impact of drone technology on infrastructure inspection, highlighting its efficiency, cost-effectiveness, and enhanced safety. Drones have the ability to access hard-to-reach areas, provide high-quality data, increase inspection frequency, and improve overall efficiency.

As technology continues to evolve, the future of drone-based infrastructure inspection promises even greater advancements, including extended range, improved sensors, multi-drone missions, artificial intelligence integration, autonomous operation, cloud-based data management, and widespread adoption of dock-based drones. With these developments, the article emphasizes that drones have become indispensable tools for assessing and maintaining vital infrastructure, ensuring its safety, reliability, and longevity.

Keywords

UAV, unmanned systems, infrastructure, inspection

Introduction

As infrastructure steadily ages, the imperative to discover innovative methodologies for its inspection and maintenance becomes increasingly pronounced. In this ever-evolving landscape of infrastructure management, one technology has been making remarkable strides in recent years, namely, the utilization of drones or unmanned aerial vehicles (UAVs). The application of drones in this context has proven to be a game-changer, enabling us to capture high-resolution imagery and data from areas that were previously challenging to access. This technological leap forward has established drones as invaluable tools for the comprehensive inspection and surveillance of vital infrastructure elements, from the towering spans of bridges and architectural marvels of buildings to the extensive networks of power lines and the sturdiness of dams. Drones are contributing significantly to the early identification of potential issues, thereby preventing minor concerns from escalating into major problems.

Building inspection with drones is fast becoming a mainstream approach in the realm of infrastructure inspections, affording us the capacity to conduct assessments of buildings and other structures more efficiently and comprehensively than ever before.

Infrastructure inspection represents a critical process that involves the meticulous examination and evaluation of diverse components constituting the bedrock of our vital infrastructure systems, including the likes of road networks, bridges, power transmission lines, and commercial edifices. The overarching objective of infrastructure inspection is to safeguard the public by ensuring that the infrastructure operates safely, efficiently, and effectively.

Infrastructure inspection also encompasses a broad spectrum of activities, incorporating visual assessments, asset management, rigorous testing, and the systematic collection of data. These inspections may be executed through manual means, harnessing the skilled eyes and hands of human inspectors, or through the utilization of advanced technologies, such as drones, sensors, or robotic systems. Throughout the inspection process, multiple facets of infrastructure integrity are scrutinized, encompassing structural soundness, wear and tear, corrosion, and the identification of potential risks that might jeopardize the infrastructure's resilience and operational efficiency.

The findings derived from infrastructure inspections are instrumental in ascertaining the overall state of the infrastructure, pinpointing areas in dire need of maintenance or repair, and prioritizing the execution of these necessary interventions. Furthermore, the information garnered from these inspections plays a pivotal role in the strategic planning of future infrastructure enhancements and upgrades, aligning the infrastructural capacity with the evolving requirements and expectations of our communities.

The significance of infrastructure inspections cannot be overstated, as they are pivotal in assuring the optimal functionality of our critical infrastructure systems. Additionally, they play a paramount role in averting potentially disastrous accidents and preserving the efficiency and effectiveness of infrastructure systems, ultimately serving as a bulwark for the safety and well-being of our communities.

UAVs transforming Infrastructure inpection

The integration of drones into the realm of infrastructure inspection represents a seismic shift in how we manage and safeguard our critical infrastructure. It's not merely a technological novelty; it's a game-changing approach that offers efficiency, cost-effectiveness, and enhanced safety, fundamentally altering the landscape of infrastructure maintenance. Traditional inspection methods often necessitate road closures, bridge shutdowns, or other infrastructure disruptions that can lead to substantial inconveniences and traffic snarls. In stark contrast, drones soar above these limitations, effortlessly accessing challenging locations and delivering real-time data, all without causing major disruptions. The key to unlocking the full potential of drone inspections lies in selecting the most suitable drone for building inspections, one that harmonizes seamlessly with the specific requirements of the task at hand.

Embracing drones for infrastructure inspections doesn't just streamline the process; it also carries a substantial cost-saving benefit. Drones present a much more economical alternative to traditional inspection methods, such as rappelling teams, bucket trucks, or elaborate scaffolding setups, while also covering more ground in less time. The financial aspect is compelling, as early detection of issues through drone inspections enables timely, cost-effective interventions, preventing minor hiccups from evolving into exorbitant problems.

Indeed, drone-based infrastructure inspection is reshaping the narrative of maintenance and repair, emerging as a linchpin in ensuring the integrity and reliability of our infrastructure systems and their management. Many facets of our infrastructure, from bridges to power lines, pose considerable hazards when it comes to manual inspection. The use of drones circumvents these dangers, sparing workers from precarious situations like heights, proximity to live equipment, or the confines of confined spaces. This not only mitigates the risk of accidents and injuries but also ensures that our vital infrastructure remains in optimal working condition.

One of the crown jewels of drone infrastructure inspection is the treasure trove of highly detailed data and imagery it bestows upon asset managers. This invaluable resource empowers infrastructure stewards to make well-informed decisions regarding maintenance planning, documentation, and the timing of interventions. The data harvested by drones can be harnessed to craft intricate 3D models, which serve as virtual blueprints for identifying structural anomalies and other potential trouble spots. Armed with this information, asset managers can sculpt more nuanced maintenance strategies, allocate budgets with precision, and establish realistic timelines for addressing issues, all underpinned by a wealth of concrete evidence. In essence, drones have elevated infrastructure management from a reactive to a proactive realm, where potential problems can be nipped in the bud, and maintenance actions are executed with surgical precision.

The adoption of drones for infrastructure inspection has ushered in a new era of efficiency and cost-effectiveness, mitigating many of the drawbacks associated with traditional inspection methods. Let's delve into the multifaceted reasons why drones represent a significant improvement in this critical field.

1. Access to hard-to-reach areas:

   Drones, equipped with advanced data collection capabilities, excel in reaching locations that are arduous or, in some cases, impossible for humans to access. These include the towering precipices of rooftops, the intricate spans of bridges, and even the imposing stacks of industrial smokestacks. This capability ensures that inspections are more comprehensive, leaving no nook or cranny unexamined. Consequently, potential issues that might have eluded traditional inspection methods are now brought to light.

2. Cost-effective:

   Embracing drones for inspections translates into substantial cost savings when compared to traditional manual inspection methods. Drones can cover vast areas swiftly and efficiently, minimizing the necessity for large inspection teams and the associated expenses of specialized equipment. The reduced financial burden allows organizations to allocate resources more efficiently, achieving a higher return on investment.

3. Enhanced safety:

   Infrastructure inspection often entails work in hazardous environments, particularly when it comes to heights or confined spaces. The integration of drones into inspection routines markedly diminishes the risk of accidents and injuries by keeping human inspectors safely grounded. This not only safeguards the well-being of inspectors but also guarantees the uninterrupted operation of critical infrastructure systems.

4. Higher quality data:

   Drones are adept at capturing high-resolution images and videos, furnishing a wealth of detailed and precise information about the infrastructure under scrutiny. This data facilitates the identification of potential issues and lays a robust foundation for comprehensive maintenance or repair planning. In essence, the visual data collected by drones is a visual dossier of the infrastructure's condition, aiding in precise decision-making.

5. Increased efficiency:

   Drones are swift and efficient, executing inspections in significantly less time than their traditional counterparts. This efficiency has a ripple effect, minimizing downtime and boosting overall productivity. Industries where downtime translates into exorbitant losses, such as oil and gas, power generation, and transportation, stand to gain the most from the time-saving prowess of drones.

6. Greater Inspection frequency:

   Failing infrastructure is a cause for grave concern, and one of the contributing factors to this is the infrequent nature of traditional inspection methods, primarily due to the time and cost involved. Drones offer the invaluable capability of conducting inspections more frequently, allowing for the early detection and resolution of minor issues before they have the chance to snowball into major problems. By leveraging drones for infrastructure inspection, we ensure not only the safety and reliability of our infrastructure but also realize significant time and cost savings.

The future of drones in infrastructure inspection is an exciting frontier, marked by constant innovation and the promise of even more transformative advancements. Drones have swiftly ascended the ranks, emerging as indispensable tools for assessing the condition of critical structures like buildings, bridges, power generation facilities, and distribution lines. Their capacity to acquire high-quality data and images from hitherto inaccessible locations has ushered in a revolution in the way we inspect and maintain our vital infrastructure.

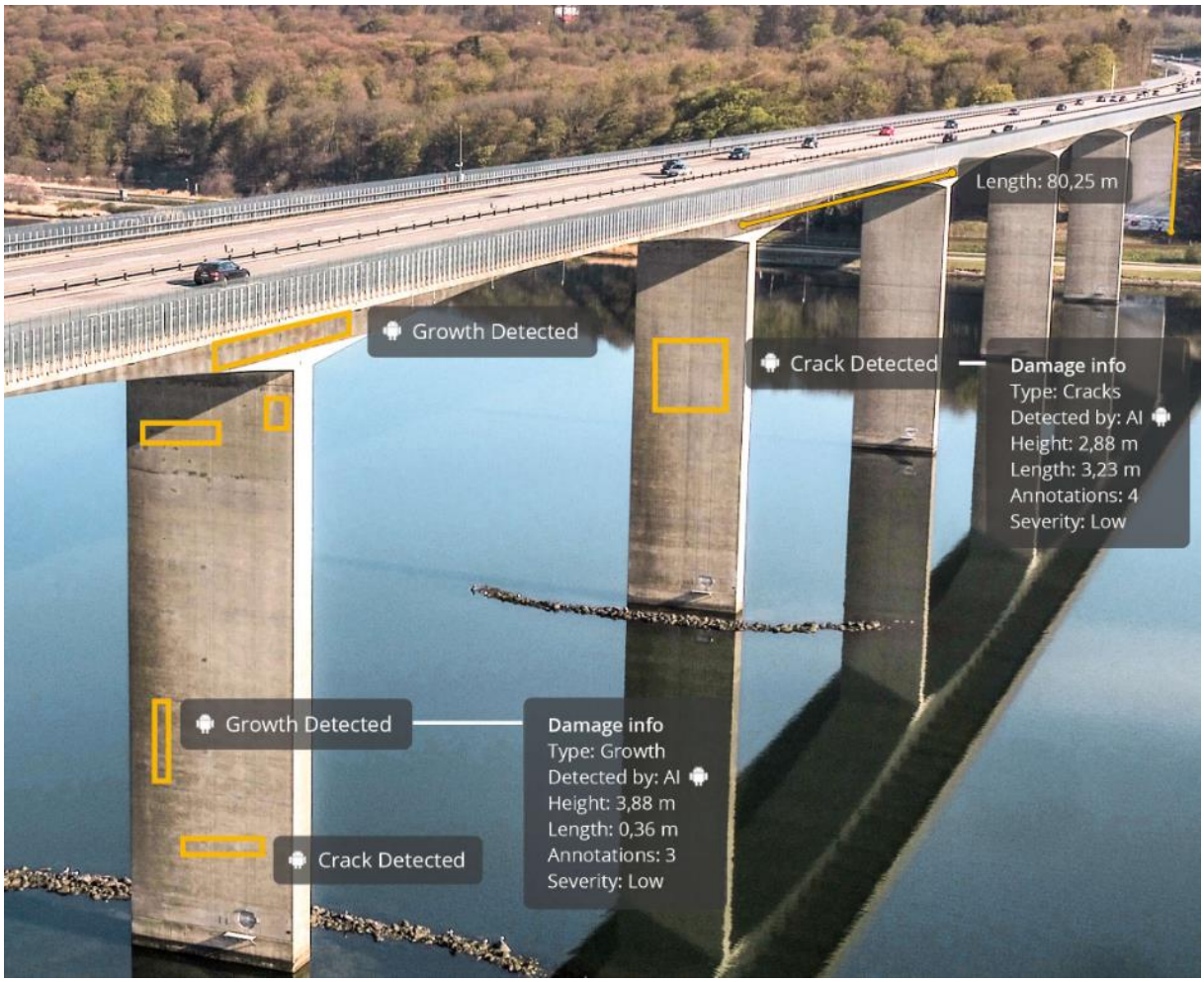

Figure 12- An illustrative instance of bridge inspection, where AI is employed to identify and analyze cracks [8]

As drone technology continues to evolve, we find ourselves on the cusp of new horizons, with a myriad of developments enhancing the capabilities of drones for infrastructure inspection. Here's a glimpse into the exciting ways in which drone technology is progressing:

1. Increased range and endurance:

   Cutting-edge drone models are under development, boasting longer flight times and extended range. These enhancements enable drones to cover more ground and remain airborne for extended durations, a boon for large-scale infrastructure projects like pipelines and transmission power lines.

2. Improved sensors and cameras:

   Drones are now equipped with advanced sensors and cameras, including thermal imaging and LiDAR technology. These upgrades yield more detailed and accurate data for inspections, facilitating the detection of potential issues that may have eluded traditional inspection methods.

3. Multi-drone missions:

   The future envisions a landscape where multi-drone missions become commonplace. As drones grow in sophistication, these missions will involve multiple drones collaborating to inspect complex structures from various angles. This cooperative approach promises more comprehensive assessments of buildings, bridges, and other substantial infrastructure.

4. Artificial intelligence and machine learning:

   Drones are increasingly integrating artificial intelligence and machine learning algorithms, enabling them to identify structural issues such as cracks or corrosion and alert inspectors to take necessary actions. This

not only streamlines the inspection process but also substantially improves post-inspection analysis and decision-making.

5. Autonomous operation:

   The future holds drones with heightened autonomy, capable of functioning without human intervention. This encompasses automatic takeoff and landing in designated docks, as well as the ability to navigate intricate environments and avoid obstacles, rendering inspections even more efficient and reducing operational risks.

6. Cloud-based data management:

   Drone technology is converging with cloud-based data management systems, allowing inspection data to be stored and analyzed remotely. This fosters improved collaboration and decision-making, diminishing the need for on-site data storage and management, a boon for streamlined operations.

7. Widespread adoption of dock-based drones:

   The continued evolution of dock-based drones is a promising trend set to reshape multiple industries. These drones offer advantages over traditional models, including increased autonomy and the potential for routine deployment without human intervention. The integration of artificial intelligence and machine learning algorithms promises to automate the inspection process further.

8. Integration with ground-based sensing:

   The future holds integrations that will amalgamate data collected from various sources, including ground-based sensors and cameras. The result will be highly accurate and detailed reports on the health of infrastructure, facilitating a holistic and comprehensive approach to inspections.

Conclusions

The integration of drones into infrastructure inspection represents a transformative leap forward in the management and preservation of our critical infrastructure. With their inherent advantages, including efficiency, cost-effectiveness, and enhanced safety, drones have redefined the landscape of inspections compared to traditional methods. They enable access to otherwise challenging locations, provide invaluable high-quality data, and facilitate more frequent inspections, ultimately ensuring the safety and reliability of our vital infrastructure.

Looking ahead, the future of infrastructure inspection is intricately linked with the ongoing development of drone technology. Anticipated advancements in extended range, improved sensors, autonomous operation, and artificial intelligence integration promise to further elevate the field. Dock-based drones, in particular, offer a glimpse into the direction this evolution is taking, providing greater autonomy and automation.

In the coming years, drones are poised to become standard tools for maintaining and enhancing our critical infrastructure, ensuring its longevity and efficiency. As these innovations continue to unfold, it is clear that the sky is not the limit but rather the beginning of a new era in infrastructure management and safety.

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20. Positive Energy Districts In European Context

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Abstract

Positive Energy Districts (PEDs) re an emerging tool in the field of energy to achieve positive results in the effort to decarbonize cities and municipalities. Several projects on Positive Energy Districts are being implemented across Europe. The aim of the article is to compile an overview of existing projects and, based on the analysis of the implemented districts, to compile an overview of the main advantages of Positive Energy Districts.

Keywords

energy efficiency; energy policy; positive energy districts; smart cities; renewable energy

Introduction

One of the greatest contemporary challenges of the 21st century is global warming as a result of human activity and increased production of greenhouse gases. The sectors of concern are mainly energy [1], housing and commercial buildings, and mobility [2]. The current "green" trend regarding the European Green Deal [3] is to increase the share of renewable sources and reduce the share of fossil fuels (non-renewable sources) in electricity and heat production and supply, to increase energy efficiency in the use of energy sources and to reduce the energy consumption of individual sectors.

The continuously increasing population of urban agglomerations brings new negative local and global impacts, such as the reduction of air quality or the warming of the planet. More than 3.5 billion people, almost 50 % of the human population, live in cities [4]. Cities consume 60-80 % of the energy produced and are responsible for 75 % of carbon dioxide production, while covering only 3 % of the Earth's surface [5]. The largest growth in urban agglomerations has been recorded over the last 100 years.

The construction of new buildings or entire districts must be planned and implemented with the environment in mind. According to European Commission data [6] published in 2020, buildings account for approximately 40 % of energy consumption in the European Union and 36 % of greenhouse gas emissions. The operational phase of buildings is undoubtedly the largest contributor to greenhouse gas emissions and energy consumption, which is why increasingly stringent legislative requirements are being introduced for new buildings, building complexes or entire neighborhoods.

The biggest challenge of the decarbonization trend is undoubtedly the need to maintain the stability and security of electricity and thermal energy supply, as well as its availability - local and affordable [7]. Decarbonization, availability, stability and security are the four most important pillars of the 21st century energy sector (Figure 1).

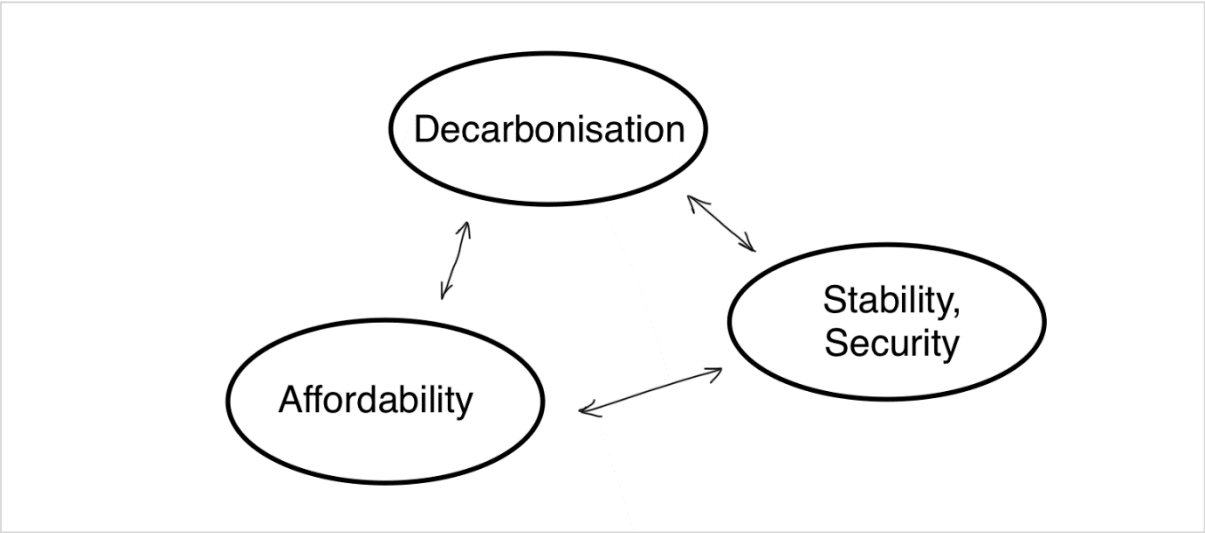

Figure 1: Energy of the 21st century, main pillars (source: author)

The Russian aggression against Ukraine in 2022 has shown the instability of fossil fuel supplies and the over-dependency of European countries on Russian supplies of fossil fuels, especially on natural gas [8]. The consequences of Russian aggression were especially unstable and uncertain energy supply and all-time high energy prices. Therefore, the main goal of the European Union is to build independent energy systems focusing on digitalization and green solutions. Crucial aspects are energy savings, diversification of supplies and renewable energy sources. In addition, 210 billion EUR will be required to achieve these goals and the main goal – to reach climate neutrality by 2050 [3].

To achieve the goals and objectives of Green Deal and other crucial documents, new energy solutions must be developed, concerning innovative technologies, innovative use of renewable energies, and innovative concepts od

energy transitions. Therefore, new concepts of energy communities were developed – Positive Energy Districts (PEDs) and Smart Cities.

A Positive Energy District is an urban area characterized by zero or negative annual energy imports and zero greenhouse gas production [9]. The goal of energy-plus neighborhoods is to minimize energy consumption, use high-efficiency systems, and cover energy consumption with local renewable resources [10]. These are energy self-sufficient locations that provide a secure energy supply while flexibly responding to changing demand, balancing peaks, and optimizing energy supply. Excess renewable energy production is integrated and delivered to the regional or national energy grid [9]. Energy-plus neighborhoods address the climate issue at the level of political, strategic, and systematic commitments to the benefit of regional development.

Together with PEDs, the new term is Smart City. Smart Cities are a sophisticated multi-disciplinary concept of cities that addresses every aspect of the city from social aspects to environmental and economic aspects. Among other things, it addresses, for example, waste collection, energy, security, or water resource management [9]. From the above, it follows that a Smart City can be a Positive Energy District and a Positive Energy District can be a Smart City at the same time, the concepts mentioned are not mutually exclusive.

This article focuses on Positive Energy District projects in the European Union and Czech Republic. Several projects are addressing this topic and implementing Positive Energy districts within the European Union. The aim of the article is to compile an overview of existing projects and, based on the analysis of the implemented districts, to compile an overview of the main advantages of Positive Energy Districts.

Methodology

An extensive desk research on the Positive Energy Districts and Smart Cities was carried out. The document "Europe towards positive energy districts" [11] which presents 28 areas that are aiming to become carbon neutral and energy self-sufficient and the article [12] about existing Positive Energy Districts in operation phase were examined and analyzed.

Results

Positive Energy District (PED) projects are emerging in various parts of the world as part of efforts to create more sustainable and environmentally friendly urban areas. These projects aim to reduce energy consumption, increase renewable energy generation, and enhance overall sustainability. The topic of Positive Energy Districts has gained considerable momentum in recent years. Most of the articles were published in 2022 or 2023. This suggests the development is rather dynamic and the topic will be interesting in the coming years. In the European Union, several independent projects are working on the topic of Positive Energy Districts. Most of the projects are funded by the EU framework programme for research and innovation - Horizon 2020 (Table 1).

Table 1: Horizon 2020 projects on Positive Energy Districts

project name/organisation	programme	duration	budget
MAKING-CITY	Horizon 2020	12/2018 – 12/2023	20 million eur
SPARCS	Horizon 2020	10/2019 – 09/2024	24 million eur
COOPERaTE	-	-	-
+CityxChange (Positive City ExChange)	Horizon 2020	11/2018 – 10/2023	24 million eur
POCITYF	Horizon 2020	10/2019 – 09/2024	22 million eur
atelier	Horizon 2020	11/2019 – 10/2024	22 million eur

Europe should be the first carbon neutral continent in the world [13] and a model for energy transition for other continents. Positive Energy Districts are a tool to achieve the European Union's goals and plans [10]. The Positive Energy District European network (CA19126) brings together 33 European countries that are participating in a project under the SET Plan, namely the creation of 100 Positive Energy Districts in Europe by 2025 [14]. It is a pilot European concept that was announced by COST (European Cooperation in Science and Technology), a research company. The aim is to harmonize, share and disseminate knowledge about Positive Energy Districts. The PED project coordinated by UCEEB and the municipality of Kladno is part of the project.

Another European programme for the implementation of Positive Energy Districts in line with the SET Plan is the PED Programme of the JPI Urban Europe group [9]. JPI is a platform or gateway that is dedicated to urban transformation and research. It is an international project with the same goal as the previous one: to create 100 Positive Energy Districts in Europe by 2050.The project seeks to achieve this goal by planning, developing and replicating Positive Energy Districts. The project is funded by the European Horizon 2020 programme and brings together 20 countries, of which the Czech Republic is not a member.

According to JPI Urban Europe group, there are 2 Positive Energy Districts in the operating phase, 18 in implementation phase and 8 in planning phase [11] (Figure 2).

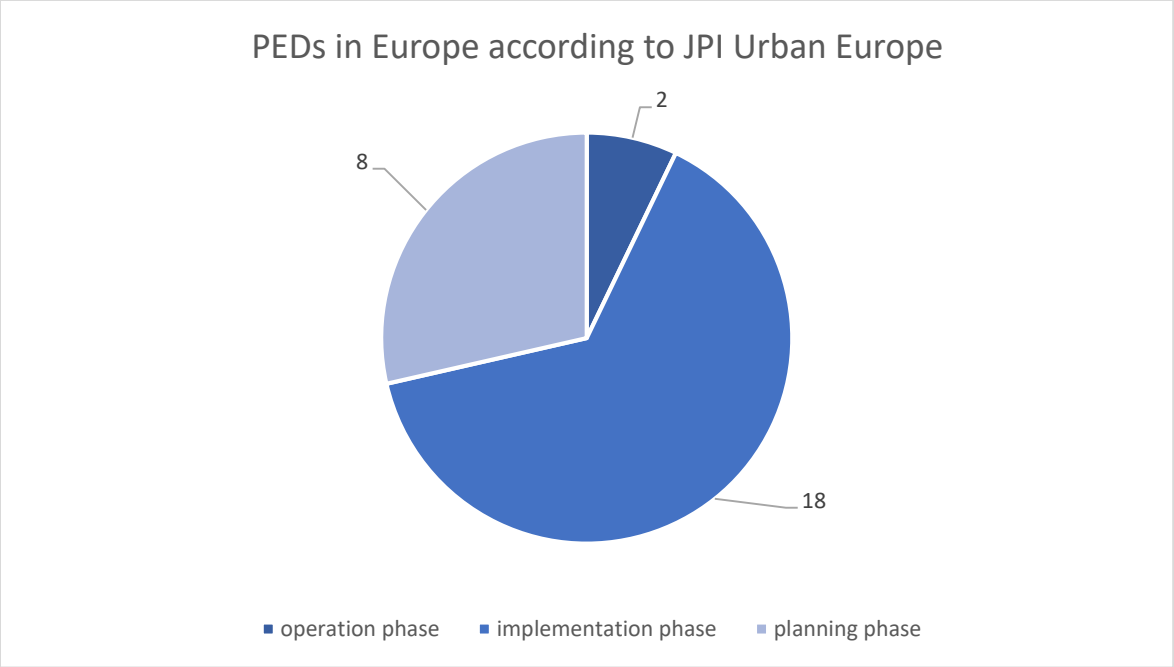

Figure 2: Positive Energy Districts in Europe according to JPI Urban Europe

There are two Positive Energy District projects in the Czech Republic, both in the town of Kladno. The first Positive Energy District is in the planning phase and is part of the SPARCS project (Horizon 2020 funding programme). The second Positive Energy District in Kladno is financed by a private investor and is in the implementation phase.

The analysis of existing Positive Energy Districts in the operational phase has shown that Positive Energy Districts have several advantages over conventional urban neighborhoods, such as:

- cost reduction due to optimization system service (optimization of power purchase from the grid and on-site generation considering the low and high tariff; economic savings: Cork, Ireland – up to 11 %, Guyancourt France – up to 15 %) [12],
- energy savings (Cork, Ireland – 0 %, Guyancourt France – up to 4 %) [12],
- CO_2 emissions reduction (PEDs are designed to reduce energy consumption and promote the use of renewable energy sources that leads to a significant reduction in greenhouse gas emissions, helping

combat climate change; up to 50 of CO_2 emissions/year can be reduced according to MAKING CITY project) [15],

- energy independence, energy security (PEDs aim to generate more energy than they consume, which leads to energy independence and energy security for the district),
- improved air quality (by reducing the use of fossil fuels and promoting sustainable transportation)
- creation of new "green" jobs (the planning, construction, and maintenance of PEDs can create job opportunities in various sectors, including renewable energy, construction, and technology; up to 4400 new jobs/project will be created according to MAKING CITY project) [15],
- enhanced quality of life (PEDs emphasize green spaces, pedestrian-friendly designs, and reduced noise pollution, contributing to an enhanced quality of life for residents).

The outcomes and results of each parameter are dependent on the stated objectives of each project. Fore example, in Bishoptown, Cork, Ireland, the aim was to achieve cost reduction and optimization, not to save energy. Therefore, the energy savings were at 0 %.

Conclusion and discussion

It is essential to transform European cities into energy efficient and self-sufficient ones and thus move towards carbon neutrality. The dependence of European cities on an unstable supply of fossil fuels from Russia is emerging as a major energy issue for 2022, 2023 and future years. Positive Energy Districts are a tool to achieve a stable, affordable, and secure energy supply and to achieve EU's goals towards climate neutrality. Positive Energy Districts provide a partial solution to the climate crisis and address energy insecurity and dependence on non-renewable resources from politically unstable countries.

The analysis has showed that transforming urban neighborhoods into Positive Energy Districts brings several benefits for their residents and users:

- cost reduction,
- energy savings,
- CO_2 emissions reduction,
- energy independence, energy security,
- improved air quality,
- creation of new "green" jobs,
- enhanced quality of life.

It's important to note that the specific advantages of a Positive Energy District can vary depending on the goals, design, and location of the district. However, in general, the concept is aimed at creating more sustainable, efficient, and livable urban areas while addressing environmental challenges.

Positive Energy District are a new concept that needs to be addressed in the future. The topic of Positive Energy District is evolving rapidly. There are several projects within the European Union dealing with the issue, which can be a model for the implementation of other Positive Energy District in Europe and worldwide. The implemented Positive Energy District prove that the concept of Positive Energy District is feasible.

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