

Development of high-rise buildings in Europe in the 20th and 21st centuries

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Europe cities with their dense historic fabrics greeted skyscrapers with a great deal of scepticism. It was not until the 1950s that Europe began to construct buildings taller than 100 meters. By 2013, skyscrapers had been constructed in over 100 European cities located in 30 different countries, and the trend towards the expansion of high-rise construction continues. Nonetheless, rarely does a comprehensive study of the development of the European high-rise buildings take place. The aim of the study is to fill in the gaps in this knowledge. In addition, the analyses aim at identifying the dominant type of high-rise buildings. Research shows that a record number of skyscrapers were completed in the first decade of the 21st century and it appears that this record might be surpassed in the next. Although Europe is currently constructing its first two supertall skyscrapers, European buildings generally do not exceed 250 meters. Today, the majority of European skyscrapers are office buildings; although in the 21st century there has been an increasingly significant tendency to equalize the quantity of residential and office buildings. Moreover, the highest European skyscrapers are designed as mixed-use buildings. Significant development continues in leading centres of high-rise office construction located in the area between the United Kingdom and Italy, in Spain, and in Central and Eastern Europe. The majority of European office towers have been built in capitals. The key centres in the ongoing office skyscrapers' development remain: Paris, Frankfurt and London.

Key words: European high-rise buildings, office towers, development

Background – high-rise buildings and historic European cities

Skyscrapers were first introduced in American cities characterized by a lack of historic buildings or historic urban fabric. Europe, while certainly not afraid of building tall structures, accepted the American skyscraper typology with a great deal of scepticism [1]. Developing high-rise buildings in European cities with historically evolved urban fabrics called for different and diversified approaches to high-rise planning - especially where these cities' identities had begun to be linked to their historic structure [2]. Prior to 1950 the United States had already completed over 200 skyscrapers in excess of 100 meters, and a few over the 250 meters limit [3]. In the early twentieth century, the objects of historical value already became symbols of the European culture, therefore, no new elements for their identification were needed [4]. Moreover, due to a belief that high-rise structures might dominate the image of cities in a negative way, high-rise buildings in Europe were isolated phenomena well below the 100 meters limit [5].

It was not until the 1950s that Europe began to develop buildings over 100 meters, which are the subject of this article. When work began on reconstructing destroyed towns and cities the rapid development of high-rise buildings resulted from the expanded demand for office and residential space, as well as the search for new, modern urban models [2]. Some of the heavily damaged cities had no choice but to rebuild carefully – integrating old and new [1]. Though the prime aim of many realizations was to use the land as

profitably as possible, skyscrapers began to symbolize the power – administrative or economic – of the towns where they were erected [6].

The cities of continental Europe have taken shape over years of reconstruction and renovation and manifest the result of many centuries of tradition and efforts of the past generations [7]. To begin the next stage in their development historic cities and their skyline must continue to evolve. A high-rise building is one of the indicators of modern era architecture, and as such had to be considered in the urban planning of many cities [8]. If a city is going to maintain its status as a modern metropolis, it must provide locations for high-rise buildings [9].

Introduction

The trend of high-rise buildings' development sparked at the end of the nineteenth century in the United States and now includes all continents, although some regions differ in their design premises. The presented historical and urban conditions resulted in a specific design of the European high-rise buildings i.e. their smaller scale, both in terms of height and quantity.

Many studies are devoted to high-rise buildings; however, the examples of the European continent are rarely studied or only partially analyzed. The studies suited for the projects around the world are often limited to buildings higher than 150 m (e.g. [10]) or 200 m (e.g. [11]) and include only the particularly high skyscrapers on the European continent. In addition, the 100-meter height divisions

used for the purposes of worldwide analysis (e.g. [11]), make it difficult to assess the height distribution of the European skyscrapers. The databases containing details of the European high-rise buildings are only tabular lists (e.g. [3], [12]). There are many studies in the European literature on tall buildings development in individual countries (e.g. [2], [13], [14]) or in the cities, which are the most common centers of locating high-rise buildings (e.g. [15], [16], [17]). The descriptions of the development of high-rise buildings on a continental scale are lacking. It should also be noted that the data presented in the literature, relating both to the functional and height divisions, refer usually to the final quantitative analyze without describing the changes in the years and decades (such as [10], [18]).

The aim of the study is primarily to fill in the gaps in knowledge on the development of high-rise buildings in Europe, with particular attention to changes in the functional and height structure. Moreover, the first analyze aim to determine the dominant type of high-rise buildings, the development and localization of which will be subjected to a more detailed analysis in the second part of the study. The ultimate goal of the research is to determine the function and the height of the skyscrapers, which will be the subject of further research.

Material and methods

The study presents the development of the European high-rise buildings. Freestanding towers and religious building were excluded from the study. The information presented was obtained from the analyses of data from *The Skyscraper Center* database [3], confirmed in numerous studies on individual buildings (e.g. [12], [13], [19] – [28]). The analyzed data related to: building's height and function, the date and venue of its construction.

According to the assumptive definition [29], the minimal height of the high-rise building is 100 meters. The presented analyses focused on the time span from 1940 (i.e. marking the construction of the first building higher than 100 meters) to 2013 and including the predictions for the years 2013-2018, compiled on the basis of data of being under construction and proposed buildings. Due to the locations of buildings with a height of over 100 meters, the analyses included 556 buildings constructed in or designed for more than 100 cities of 30 European countries (i.e. Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Czech Republic, Denmark, Estonia, France, Germany, Greece, Italy, Latvia, Lithuania, Luxembourg, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom).

The development research of the high-rise buildings in Europe was divided into three parts. The first analyzes the overall development of the entire buildings taller than 100 meters, and the collected data were compared with regard to the decades. The second part of the study presents the

more detailed development of office and mixed-use buildings. The third part includes the locations of high-rise and mixed-use buildings, including the division into buildings constructed in the twentieth century, in the twenty-first century, and those being under construction.

The quantitative analyses were performed by making two systematics: relating to height and functionality. The first one includes 4 height groups: from 100 m to 150 m, from 150 m to 200 m, from 200 m to 250 m and more than 250 m. The second division consists of four functional groups, i.e. buildings: office, residential and hotels, mixed-use and other (e.g. educational, exhibition and hospital). In addition, for the purposes of presenting locations of high-rise office and mixed-use buildings more accurate height divisions were applied (see Figures 4, 5, 6).

Development of European high-rise buildings

The majority of 20th-century skyscrapers (over 100 meters tall) were completed in the late 1960s, in the 1970s and in the 1990s. The buildings erected were mostly office towers under 150 meters in height. Typical high-rise residential and hotel buildings were not higher. Over a period of 50 years only a few skyscrapers exceeding the 150-meter mark were constructed and the highest of them is an office building over 250 meters tall.

To date, the record for the number of skyscrapers completed was set in the first decade of the 21st century. However, it appears that this record might be surpassed by the current decade. In the 21st century an increasingly significant trend has been the tendency to equalize the number of constructed high-rise office and residential buildings, as well as the growing number of mixed-use realizations, especially among the tallest skyscrapers.

High-rise buildings completed in the 21st century are mostly residential and hotel buildings between 100-150 meters tall. The second largest group consists of office buildings also between 100-150 meters tall. In the height range between 150 meters and 250 meters it is the other way around: the majority of newly-erected skyscrapers have office functions and the second group consists of residential buildings. Today, the tallest European skyscraper is a mixed-use tower over 300 meters in height. Among the tallest (over 250 meters tall) buildings are also some residential buildings.

Still, the majority of European skyscrapers under construction are under 200 meters tall. The height range between 100 meters and 150 meters is dominated by residential towers, but the range between 150 meters and 250 meters is dominated by office buildings. Skyscrapers set to exceed 250 meters in height are mostly mixed-use objects. The tallest building under construction is an office tower, but it will be an exception to the rule: the tallest European skyscrapers are and probably will continue to be designed as mixed-use objects [5].

Development of high-rise buildings in Europe in the 20th and 21st centuries

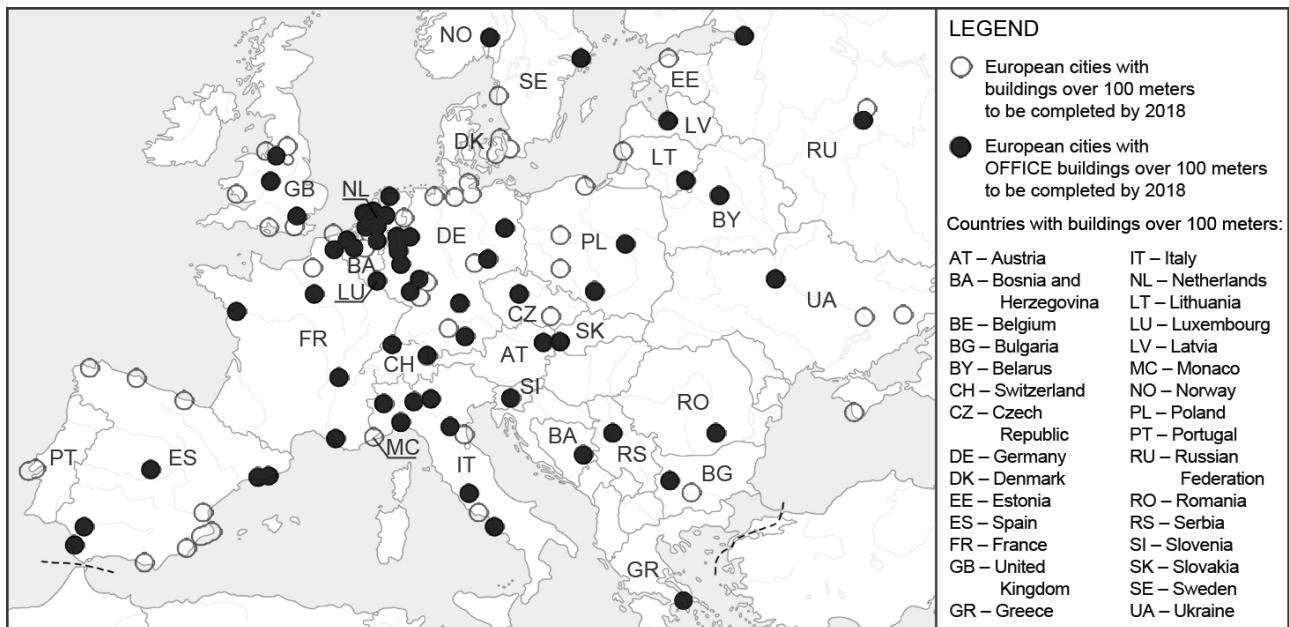


Figure 1. Projection of European cities with buildings over 100 meters in height by 2018

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

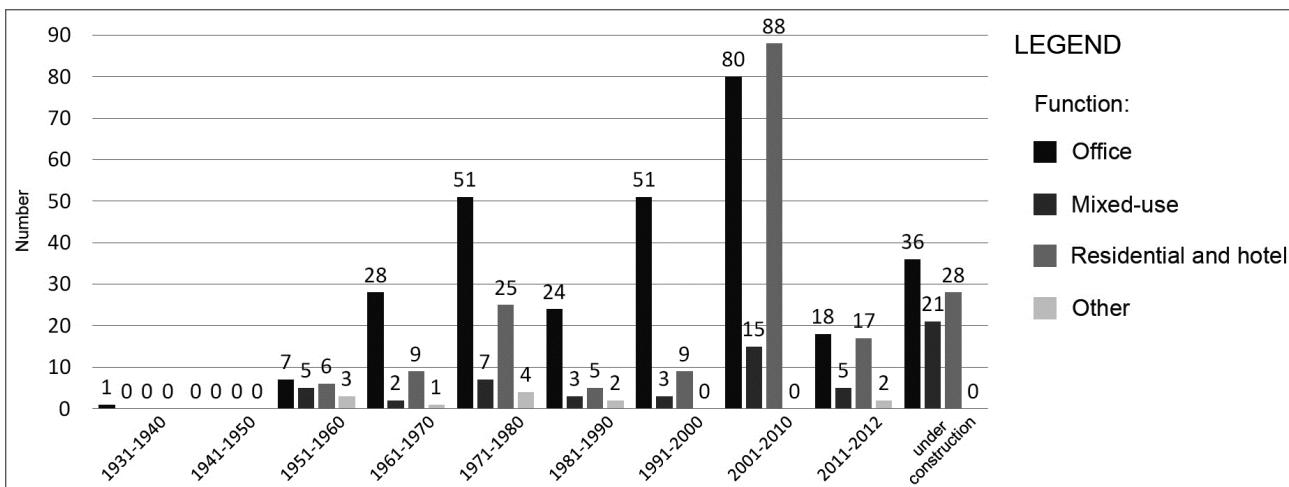


Figure 2. European high-rise buildings, 100 meters or taller, completed each decade and under construction: by function

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

Development of office and mixed-use buildings

Skyscrapers are an unmistakable demonstration of progress, prosperity, economic power, and an answer to investors' desires for centralized office space and prestigious headquarters. And for that reason the largest group of European skyscrapers consists of those with an office or mixed-use function.

Most of the high-rise office buildings in Europe are less than 150 meters in height. At the end of the 20th century office towers exceeding the 150-meter mark were very uncommon, and towers over 200 meters in height were iso-

lated phenomena. In the first decade of the 21st century the number of completed office buildings between 150 meters and 200 meters grew, and now this is the dominant group of buildings under construction.

In the 20th century the European scale of high-rise office buildings was defined by buildings less than 200 meters tall. In the 21st century more and more skyscrapers taller than 200 meters have been built, but still the average European scale has been a height between 100 meters and 200 meters. Towers exceeding 200 meters in height are significant or record-breaking structures in Europe, although they are too short to compete in the worldwide height race.

Table 1. Number of European high-rise buildings, completed in the 20th, 21st century and under construction: by function and height

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

| Function | Height: | | | | Total number |
|--|----------|----------|----------|-------|--------------|
| | 100-150m | 150-200m | 200-250m | >250m | |
| Number of European buildings completed in the 20th century | | | | | |
| Office | 138 | 17 | 5 | 2 | 162 |
| Mixed-use | 17 | 2 | 1 | - | 20 |
| Residential and hotel | 50 | 3 | 1 | - | 54 |
| Other | 9 | - | 1 | - | 10 |
| Total number | 214 | 22 | 8 | 2 | 246 |
| Number of European buildings completed in the 21st century | | | | | |
| Office | 70 | 20 | 7 | 1 | 98 |
| Mixed-use | 16 | 1 | 2 | 1 | 20 |
| Residential and hotel | 83 | 17 | 2 | 3 | 105 |
| Other | 2 | - | - | - | 2 |
| Total number | 171 | 38 | 11 | 5 | 225 |
| Number of European buildings under construction | | | | | |
| Office | 10 | 15 | 8 | 3 | 36 |
| Mixed-use | 6 | 7 | 3 | 5 | 21 |
| Residential and hotel | 19 | 7 | - | 2 | 28 |
| Total number | 35 | 29 | 11 | 10 | 85 |

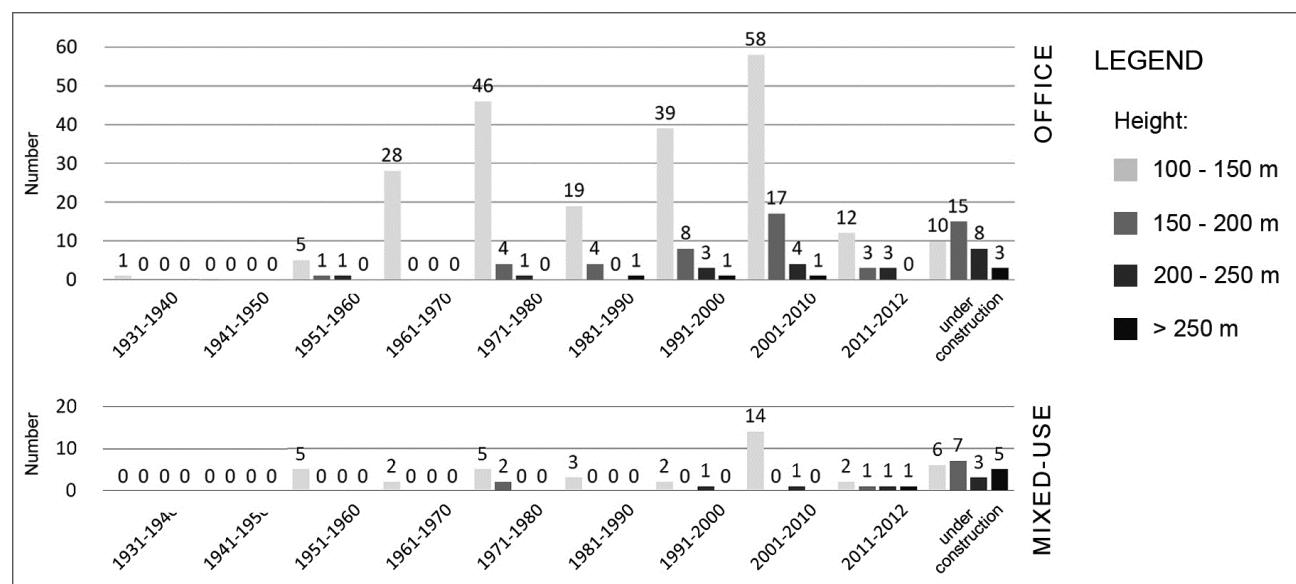


Figure 3. European high-rise office and mixed-use buildings, 100 meters or taller, completed each decade and under construction: by height

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

Development of high-rise buildings in Europe in the 20th and 21st centuries

In the 20th century mixed-use skyscrapers were generally rare and were less than 150 meters in height. This functional group grew in the first decade of the 21st century, but still is very small compared to other functions. However, there has been a very significant tendency to increase the number of mixed-use skyscrapers among realizations higher than 200 meters, especially those exceeding 300 meters.

During the past years the single-use skyscraper has been criticized because of its isolated and cumulated monofunctional area which is exploited only by one social group. Therefore, the less dynamic growth in the number of office buildings higher than 200 meters is the outcome of the trend to design flexible, multifunctional skyscrapers [5].

Locations of high-rise office buildings

In the 20th century high-rise office buildings mostly were located in Western Europe, in the area from the United Kingdom, Belgium, The Netherlands, Germany, and France to northern Italy. In the East skyscrapers were located primarily in Moscow. In this time period a few buildings were also erected in Central and South-Eastern Europe as well as in Spain.

Only in Germany were office towers completed in over 5 cities. Between 2 and 4 centres developing this type of high-rise constructions were established in France, the

United Kingdom, The Netherlands, Italy and Spain. In the remaining 11 countries office skyscrapers were erected only in capitals.

By 2000 high-rise office buildings were located primarily in Paris (31 objects). Other centres leading in the development of high-rise construction were first of all Frankfurt (18) and London (14), and also Warsaw, Naples, Brussels (9), Madrid, Berlin (7) and Moscow (6). The tallest office buildings (exceeding 250 meters in height) were completed in Frankfurt. Skyscrapers from the second-tallest group (over 200 meters) were located in Warsaw, London and Paris. Office buildings with heights ranging between 150 meters and 200 meters were erected mostly in Paris and Frankfurt, and as single realizations in London, Madrid, Moscow, Barcelona and Rotterdam. In the majority of cities in which skyscrapers were completed, high-rise office buildings were less than 150 meters tall.

In the 21st century the growth of high-rise office buildings occurred in both established skyscraper cities (cities located in Western Europe and Spain, as well as Warsaw and Moscow) and new markets, especially in Western Europe. By 2013 office towers were completed in a few cities in The Netherlands (7), Germany (5), Spain (4), Italy and France (3) and in single cities in the next 15 countries.

By far the largest European high-rise developers in the 21st century were: London (10 realizations), Paris (8) and

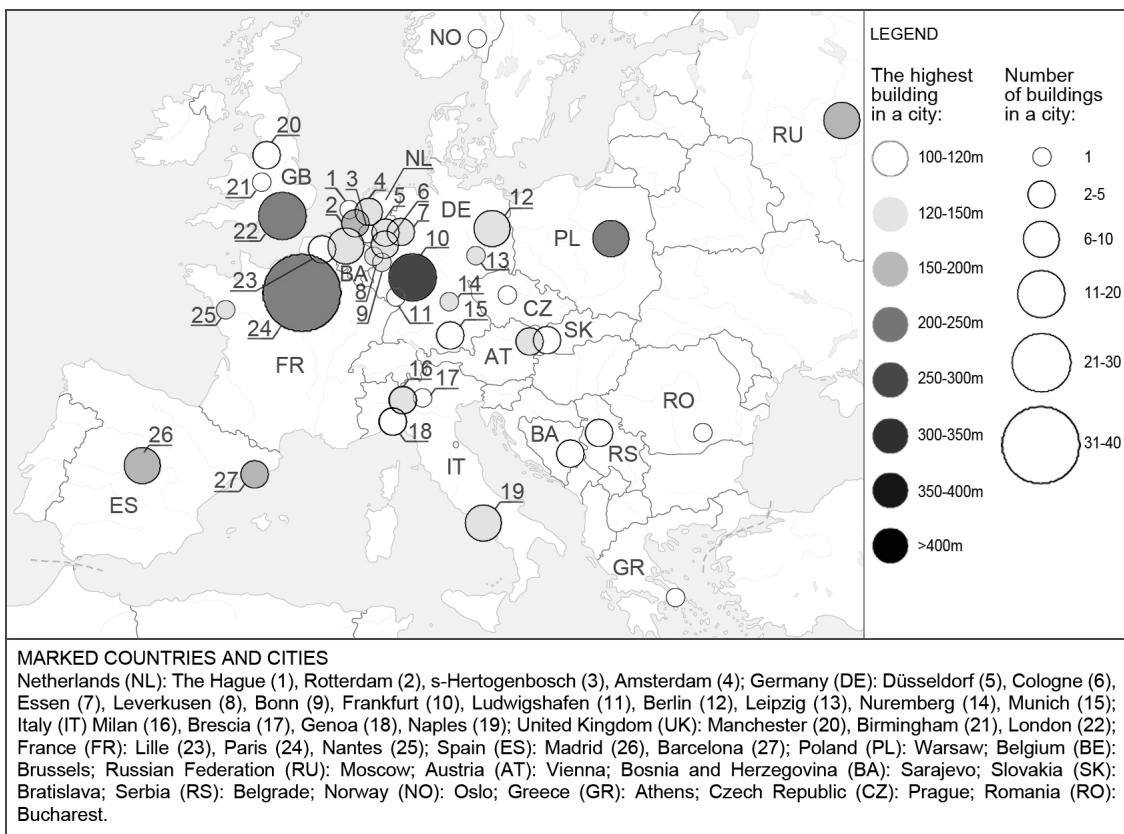
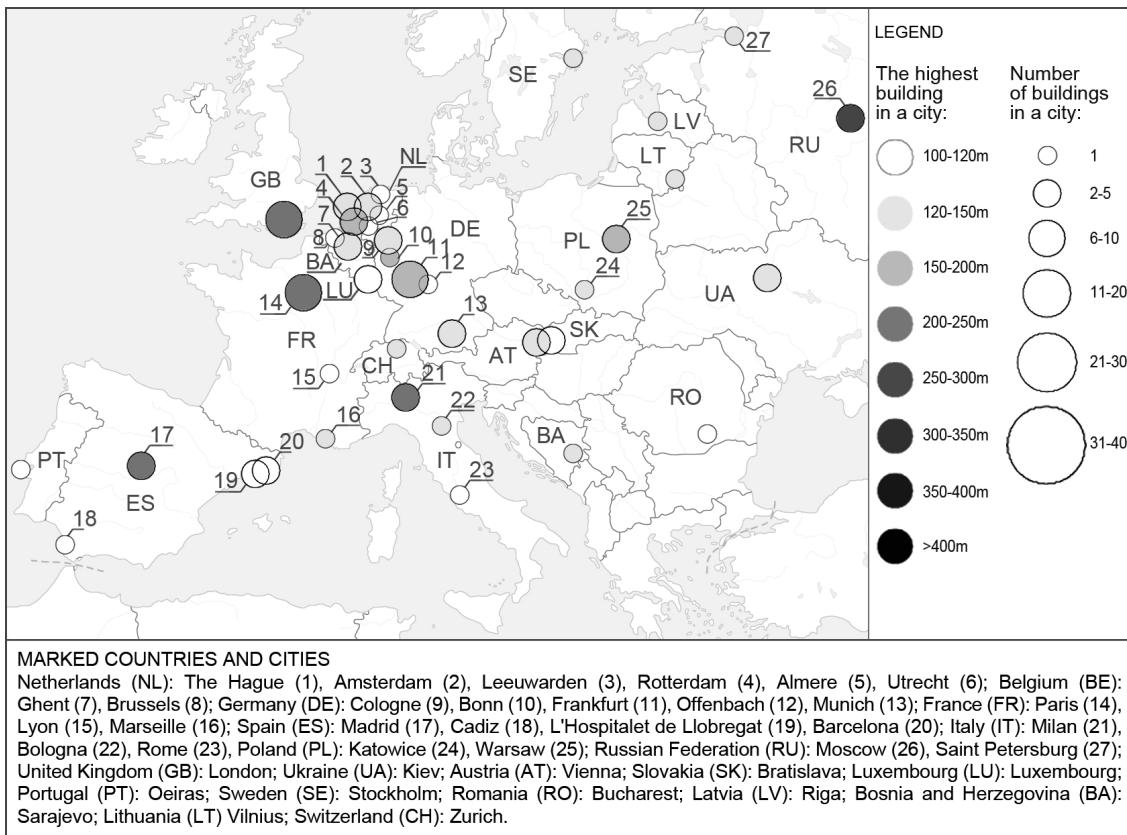
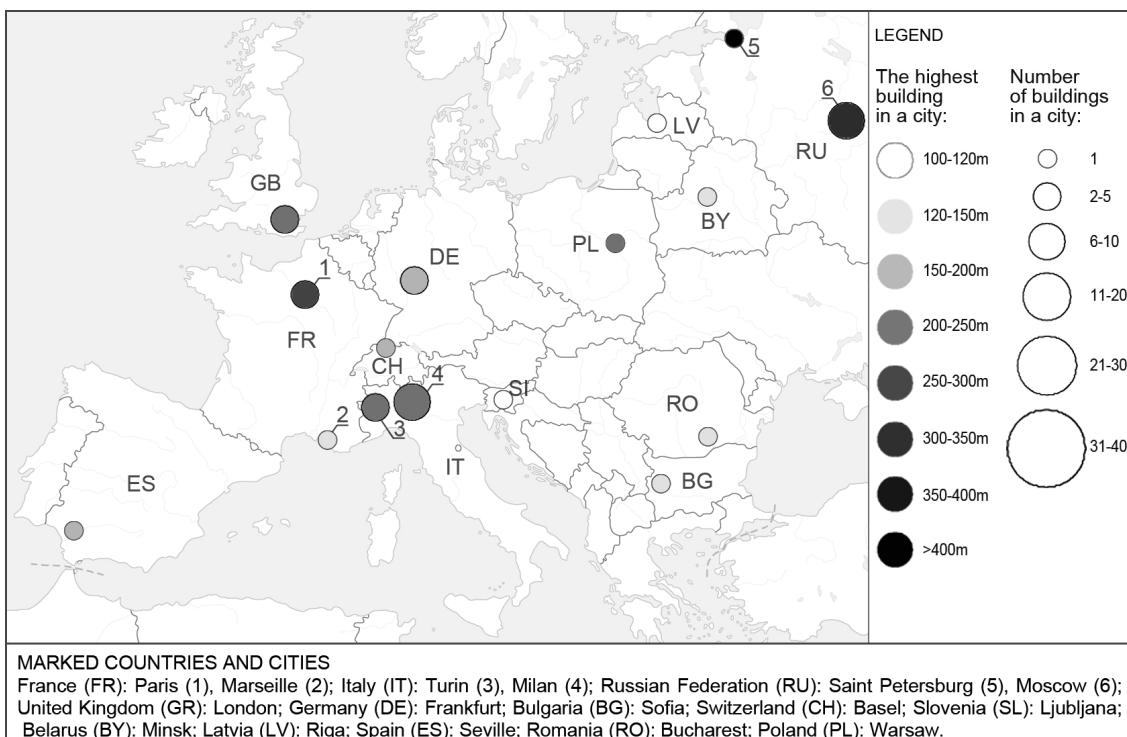


Figure 4. High-rise office buildings completed in the 20th century: by cities

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

**Figure 5. High-rise office buildings completed in the 21st century: by cities**

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

**Figure 6. High-rise office buildings under construction: by cities**

Note. Own work based on data from The CTBUH Tall Building Database – The Skyscraper Center, retrieved on 25.05.2013 from <http://skyscrapercenter.com>

Frankfurt (7). Smaller groups of office skyscrapers were constructed in: Kiev and Moscow (5 buildings in each), Munich, Milan, Brussels, Amsterdam and The Hague (4). In this time period the tallest office building (over 250 meters in height) was built in Moscow. Other very tall skyscrapers exceeding 200 meters were completed in Madrid, London, Paris and Milan. Office buildings with heights ranging between 150 meters and 200 meters were erected in London, Paris, Frankfurt, Moscow, Bonn, Rotterdam, Milan and Warsaw.

Office buildings set to be completed by the end of 2018 are designed for established skyscraper regions, but also for cities without buildings exceeding 100 meters. Western Europe (from the United Kingdom to Italy) continues its significant high-rise development, and the same is true of Eastern and South-Eastern countries. Scandinavia is still the European region almost entirely without skyscrapers.

At the moment skyscrapers are under construction in 13 cities. Only in Italy, France and Russia are two such cities located; the rest are dispersed – one city in each country. Only in Moscow, Milan, Paris and London are groupings of 5-6 office buildings scheduled for completion before 2018.

By 2018 the tallest office building (463 meters tall) will be completed in Saint Petersburg, and other supertall skyscrapers (over 300 meters) will be constructed in Moscow. Outside Russia very tall buildings over 250 meters tall are designed only for Paris, but office towers over 200 meters will be erected in 4 more cities: Milan, London, Turin and Warsaw.

Discussion

By 2013, skyscrapers in Europe had been constructed in over 100 cities located in 30 countries and the trend towards the expansion of the construction of high-rise buildings continues. Since tall buildings in Europe exist in predominantly low-rise and often ancient urban contexts, skyscrapers here more easily achieve a spectacular contrast and become famous, even without being supertall.

Since the 1950s the number of European skyscrapers has continuously increased, and this development has always been linked mostly with office buildings. Despite the tendency to equalize the quantity of residential, mixed-use and office buildings this last function is still very significant. The majority of the tallest and most spectacular European projects were office buildings.

Recently very high towers have been characterized by mixed-use instead of being designed only as offices. The other tendency is the growth in the number of non-office high-rise buildings and the transformation of monofunctional districts into ensembles of different functions.

In the 20th century the majority of high-rise buildings were completed in Western Europe in the area from the United Kingdom to northern Italy. During this period some skyscrapers were also erected in Spain, Central and

South-Eastern Europe. In the East the only tall buildings centre was Moscow. In the 21st century skyscrapers were constructed mostly in established skyscraper cities (cities located in Western Europe and Spain, as well as Warsaw and Moscow) and new high-rise centres in Eastern Europe. Tall buildings centres located in the area between the United Kingdom and Italy and in Central and Eastern Europe continue to see significant or record-breaking development of office towers (set to be completed by the end of 2018).

The majority of European skyscrapers have been built in capitals, exceptions being centres in countries with a few cities in which high-rise office buildings were constructed, like The Netherlands, Germany or Italy. The key centres in the continuous development of office skyscrapers remain: Paris, Frankfurt and London. The other cities which have led office skyscraper development for a long time are: Moscow, Brussels, Warsaw, Madrid, as well as Cologne, Amsterdam, Munich, Wien, The Hague and Bratislava. There is also a group of cities in which buildings exceeding 100 meters were completed only in the 20th century (for example Naples, Berlin) or were dynamically implemented in the 21st century (for example Kiev, Turin or Milan).

The expansion of high-rise office buildings started in the 21st century and this trend will probably continue. That tendency is noticeable in analysis based on projects begun and scheduled for completion before 2018. It is also worth noting that European skyscrapers continue to be focused more on functionality and context, and less on achieving impressive heights. Although Europe is completing its first two supertall skyscrapers (projects in excess of 300 meters), the average European high-rise building is about 130 meters tall.

Conclusions

The European scale of high-rise buildings in relation to the global skyscrapers' heights (compare [10] and [11]) is limited. The erected European buildings, with the exception of the Russian projects, generally do not exceed 250 meters. This results in a low interest among worldwide researchers with the European tall buildings. The state and development of the local high-rise buildings still remains in need of more accurate analyses.

Despite the skepticism which accompanied the introduction of high-rise buildings in Europe as well as some recent negative opinions on the erecting skyscrapers in the European cities, this type of buildings is more and more popular on the continent. To sum up the three main periods of the high-rise buildings growth (the turn of the 60s and 70s of the twentieth century, the 90s of the twentieth century and the twenty-first century), one can notice that the number of skyscrapers being built gradually increased, as well as their height and the number of cities in which the tall buildings are erected. Based on the analyses of proposed buildings and those currently under construction, it can be concluded that the overall number of high-rise

buildings in Europe, and particularly the number of the highest projects, will be increasing. In addition, skyscrapers will change the urban fabric in a growing number of European cities. Therefore, the need for further research of this type of building, which affects and will affect the evolution of the European skyline, is justified.

The analyses presented in this study allow for a better understanding of the functional and the height structure of the European high-rise buildings. Research also shows the office buildings as a dominant and fast growing skyscrapers' type as well as mixed-use as the right function for the highest buildings. The study presents all the cities with completed high-rise buildings or skyscrapers under construction, both with office or mixed functions. Based on these premises, the dominant regions in the construction of high-rise buildings were designated. While the average European high-rise building is about 130 meter high and a group of buildings of less than 150 meters is quite large, it can be assumed that buildings with a height of 150 - 250 meters constitute generally the European skyscrapers, i.e. the highest buildings on the continent.

The analyses also aimed to determine the further object of the author's research. The results allowed determining the mixed-use and office buildings reaching 150-250 meters as the subject of further research. Based on the current analysis, the buildings erected after 2000 will dominate in this group.

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