BUDAPEST

Environmental protection in Budapest

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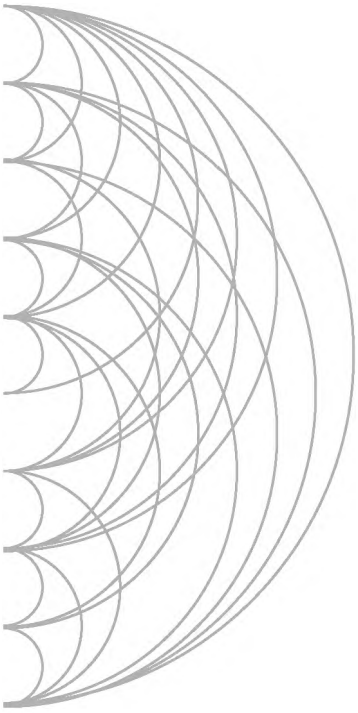


Impact factors – affected factors

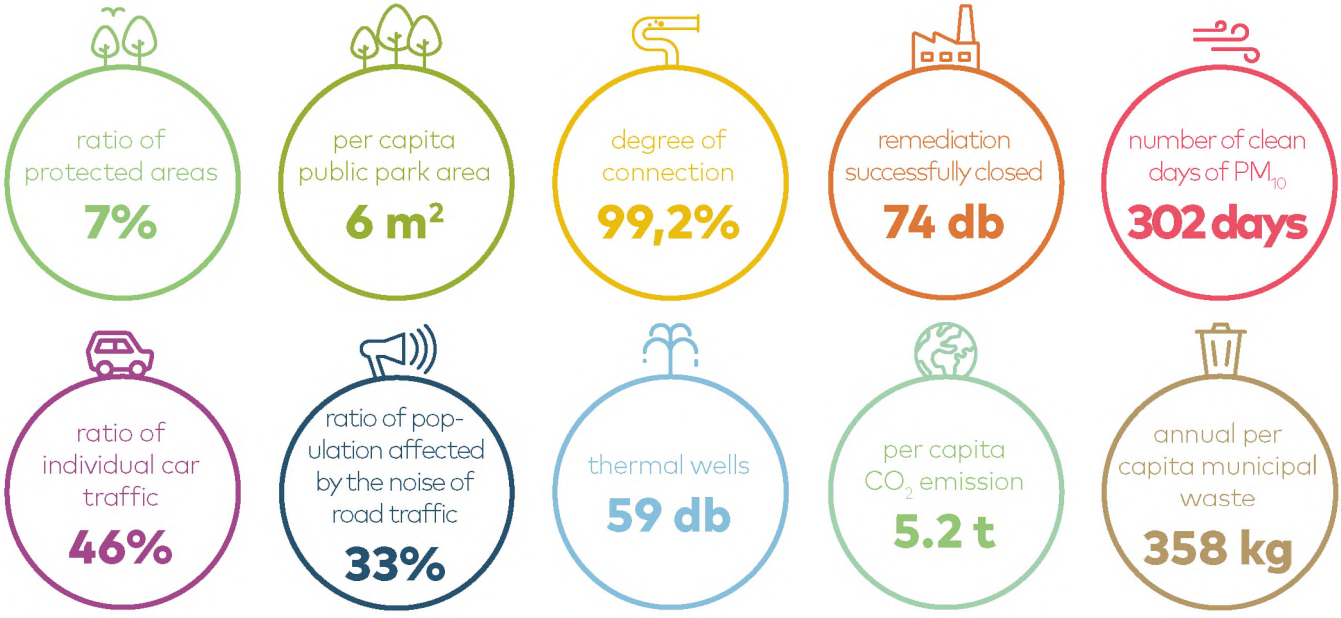
Protecting our environment

The Municipality of Budapest is committed to improving the status of environment in the city. Over the past few years a number of measures were taken that are aimed at establishing a healthy environment. The status of the components of the environment and the processes and impacts affecting them must be analysed before the right actions can be defined. Consequently, the Municipality of Budapest prepares an environmental assessment of the city each year, reviewing the changes taking place in the condition of each environmental component in Budapest over the past few years and decades.

The purpose of this publication is to briefly and clearly present the main achievements and findings of the environmental assessment to the local residents, employees and visitors of the city and to everyone – non-Hungarian speakers in particular – who are interested in Budapest.

Learn more
The annual environmental assessments are available in Hungarian at ***budapest.hu****.*

Following a general description of the city, the publication describes the environmental status of Budapest through the various components of the environment and the factors affecting it. In each chapter the characteristics and achievements of the city are presented through international comparisons. In addition, we also present major or exemplary and progressive measures already completed or still in progress in Budapest.



Significant indicators of Budapest's environmental status, based on the detailed status assessment's data of 2017

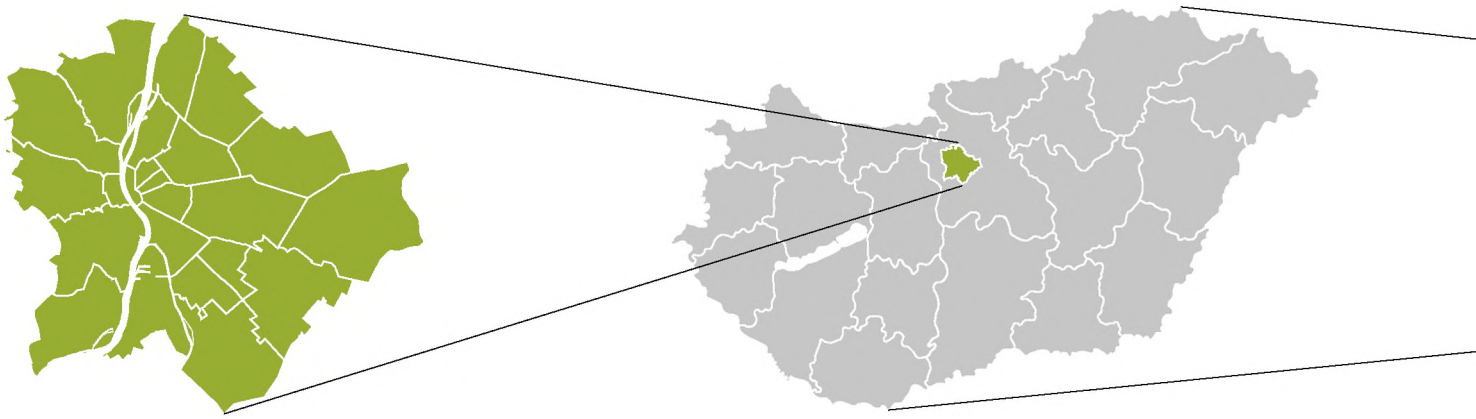
Budapest in a nutshell

Budapest

area: 525 km^2
population: 1.752.704 inhabitants (15th in Europe)
population density: 3.338 inhabitants/km^2
GDP per person: 22.900 EUR/inhabitant
territorial subdivisions: 23 districts

Hungary

area: 93.030 km^2 (18th in Europe)
population: 9.778.370 inhabitants (19th in Europe)
population density: 105.1 inhabitants/km^2 (19th in Europe)
GDP per person: 12.673 EUR/inhabitants
territorial subdivisions: 19 counties + capital



Budapest in international comparison

Population density (person/km²)	*GDP (EUR/person)*
3.338	**22.900**
1.649	27.800
3.242	n.d.
4.576	48.300
9.242	21.800
4.681	72.600
2.623	33.600
3.414	32.100

Key events of Budapest's history

Hungarian conquest of the Carpathian Basin

The Hungarian tribes occupied territories to the west from the Danube in 900.

IX

The capital of the Hungarian kingdom

By the beginning of the 15th century Buda became a permanent royal court, with german majority of population. Pest, the hungarian-speaking city, became the center of the agricultural trade.

XIII

Enlightenment in the Habsburg Empire

Buda, Óbuda and especially Pest began to develop in the Habsburg Empire adopting new settlers, civilians and craftsmen.

XVIII

Roman period

The written history of the territory of Budapest began with *Aquincum*, a Roman military base, founded on the western bank of the River Danube around 89 A.D. (the territory is currently used by *Óbuda*).

Tatar invasion and the new city

In 1241-42 the Mongols destroyed Pest and Óbuda. Some years later, a new city, the historical center of today's city was created which became the principal city of the country and sometimes royal court.

The period of Ottoman rule

From 1526, but mainly in 1686 every part of today's city suffered heavy war damages. The population was exchanged several times in Buda.

Revolution and freedom fight

The revolution broke out in Pest on 15 March 1848, Pest became the seat of the parliament and the Hungarian government. The war ended in the summer of 1849 resulted by the Russian intervention supported Habsburgs. Buda suffered heavy damages in the course of war.

World War II

In 1944-45 the city suffered unprecented damages, hundreds of thousands of people lost their lives. The world wars interrupted the development of the city; during WW II a large number of public and residential buildings, the bridges and also the Buda Castle were destroyed.

From the change of the political system to date

The population of Budapest was diminishing from the change of the political system in 1989 until the recent past and, simultaneously, similarly to other large European cities, the former structure of industry was also transformed and the service sector became dominant. These days Budapest is the most advanced area in the country and is a major city in Central Europe.

XIX

The age of reforms

Primarily, as a result of a national movement (between 1825-1848), the cities became the centre of literary and intellectual life. That was the time when the *Chain Bridge* and the *Hungarian National Museum* were constructed, that became the emblems of the development of the cities in the country and on both sides of the Danube.

XX

The period of the Dualism

After the *Austro-Hungarian Compromise* of 1867, resulting from the merger of Buda, Pest and Óbuda, Budapest was created in 1873 and it became one of the capital cities of the Monarchy. Significant constructions of the period were the *Royal Palace of Buda*, the *Parliament*, the *Andrássy street* with the underground, and the bridges.

XXI

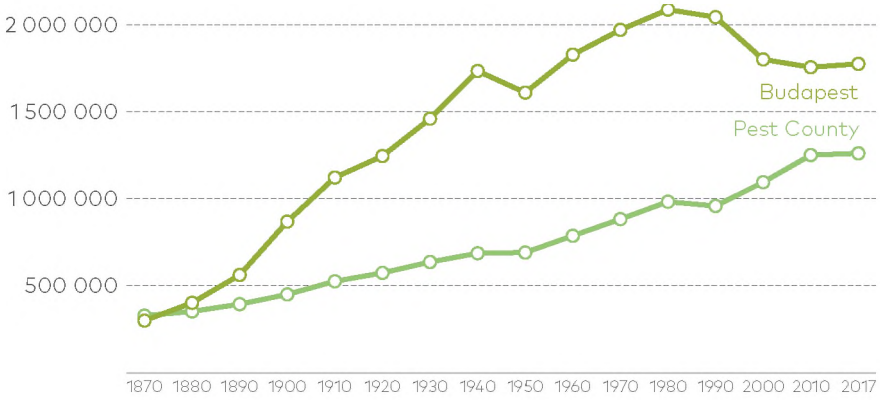
Age of communism

'Great Budapest' was established in 1950 and, as a result of another major demographic boom, population get over 2 million in 1980. As a result, large housing estates were built across Budapest from the 1960ies.

Population

After almost thirty years of decline, the population of Budapest is slightly growing again, the residential population grew by almost 40.000 since the lowest figure measured in 2007. The population is relatively homogenous in terms of language and ethnicity but the number of foreigners increased significantly over the past twenty years, making up 4.4% in the total population of Budapest. Due to the wages higher than the average in Hungary, the approximately 1.7 million residents, which is 17% of the population of the country, represent the largest consumer market in the country with a considerable impact on the environment.

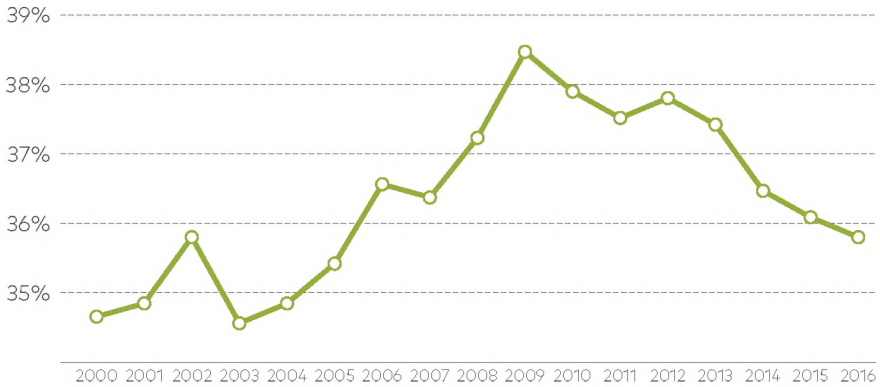
Population of Budapest and Pest County from 1870 to date (Source: KSH)



Economy

Given its leading role in the economy, the performance of Budapest is a major component in the gross domestic product (GDP). In 2016, in total, HUF 12.800 billion gross domestic product was generated by Budapest, which equals 36% of the national figure. The economy in Budapest is clearly driven by the business associations operating in the service sector. Within certain service sectors (e.g. ICT sector) the degree of contribution to the gross added value has reached 70% while agriculture has 1.5%, industry 20.3% and construction industry 23.4% share according to 2014 figures.

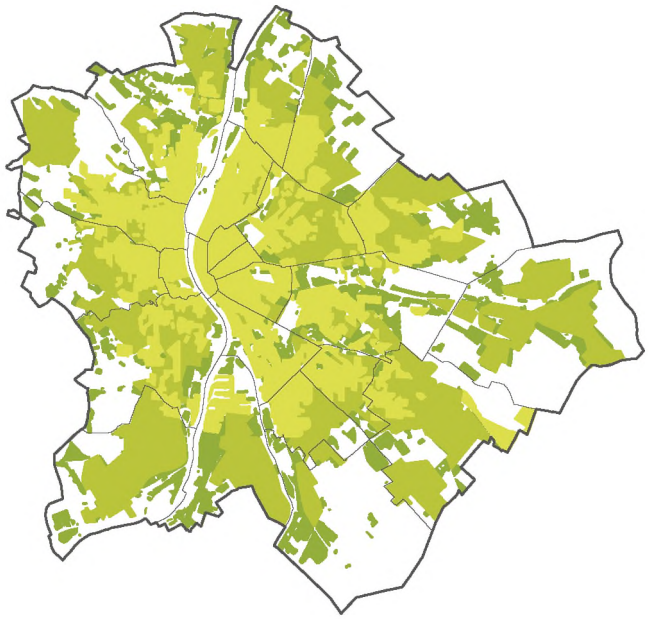
Contribution of Budapest to the gross national product



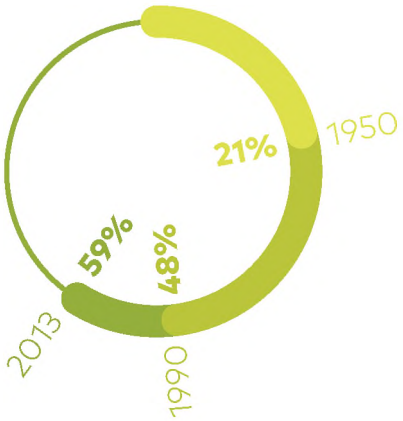
Land use

52% of the 525 km^2 area of Budapest is built-on land, 48% is unbuilt. The built-on areas of *'Great-Budapest'* formed in 1950 almost tripled over the past fifty years, reflecting on average 0.6% growth a year (313 ha/year) i.e., that is how much the open space of the city decreased.

The majority of the territory of the city is residential area. Within that 28% of the population live in intensively built-in unbroken rows of buildings, which make up 10% of the total residential area. This territory is primarily the historic downtown area. The first housing estates appeared after World War II and they were built until the systemic change. Although the housing estates make up only 12% of the residential area, 34% of the population of Budapest live in them. However, the majority of the residential buildings of Budapest are detached houses (78%) used by 38% of the residents.



Built-on area between 1950 and 2013



Distribution of the use of land, 2018

29% Residential area

17% Other built-on area

18% Transport areas

12% Agricultural area

14% Semi-natural areas

5% Areas not in use

3% Water surface

2% Public parks

Natural geography

The justifiably world famous view of Budapest is determined by its typical natural characteristics. The Danube valley divides the city into two parts: the *Buda Hills* are on the right bank of the river and the *Pest Plain* stretches on the left bank. Other small water courses add to the variety of the terrain of the city. Owing to the variety of its natural geography, within the city boundaries of Budapest hilly and plain as well as forest, meadow and aquatic flora and fauna exist side by side; valuable caves, springs, rocks, marshes and swamps as well as lakes are protected in the city.

Saker

Blue tit

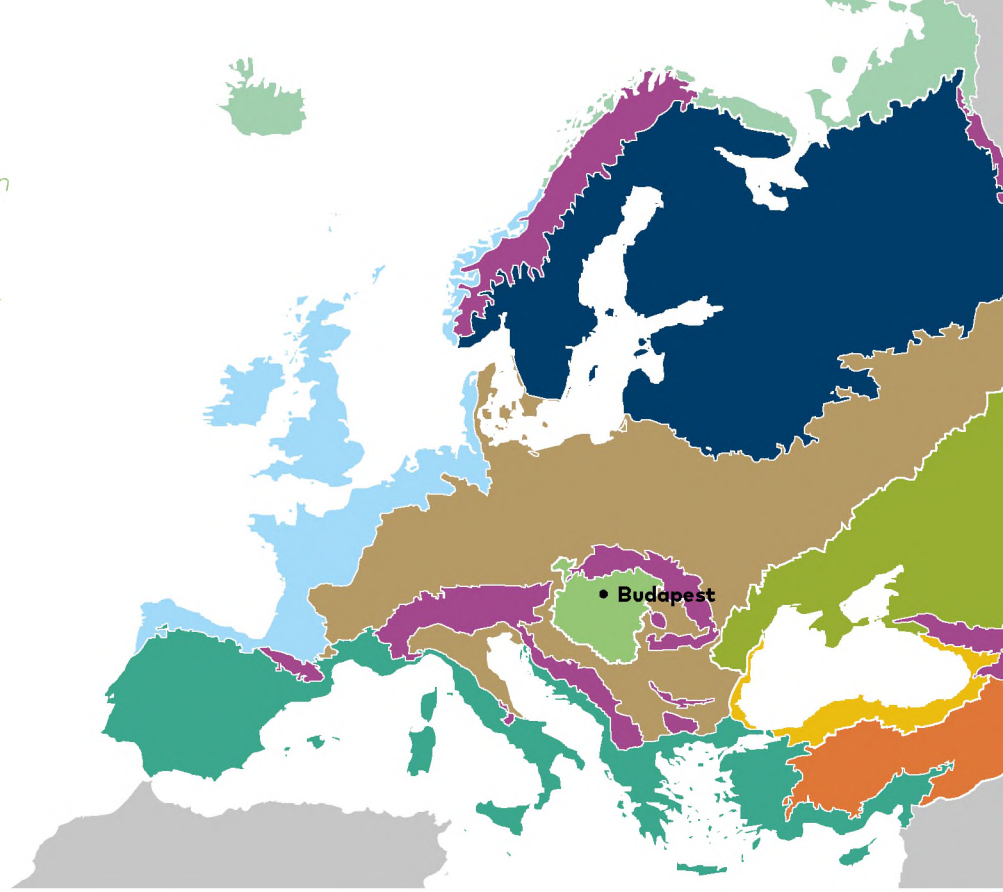
Zerynthia polyxena

Acrida ungarica

The *Pannon biogeographic region*, which is making up just 3% of the total territory of the European biogeographic region, is especially important also in terms of avifauna; 65% of the Hungarian bird species also exist in Budapest and 110 species regularly breed there every year. The most remarkable nesting species include white-tailed eagle (*Haliaeetus albicilla*), Eurasian scops owl (*Otus scops*), raven (*Corvus corax*), European bee-eater (*Merops apiaster*) and little owl (*Athene noctua*).

Of the insects the last Hungarian habitat of *Chondrosoma fiduciaria*, *Dioszeghyana schmidti* are in Budapest and the last habitat in the Carpathian Basin of Damon Blue (*Polyommatus damon*) is in *Harangvölgy* near *Normafa*.

Budapest, the largest settlement in the Pannon biogeographic region, accounting for less than 3% of the EU territory, has a unique biodiversity by European standards.



Biogeographic regions of Europe

Of the 2.700 indigenous plant species of Hungary, more than 1.400 species exist in Budapest and 197 of them are protected by law, 14 species are subject to enhanced protection. The unique status of Budapest in terms of nature conservation is strengthened by the exclusive presence of large protected semi-natural areas and certain protected plant species. Three protected plant species – Hippophae (*Hippophae rhamnoides*), *Silene flavescens*, *Anchusa ochroleuca* – have their natural habitats only in Budapest in the country.

Ophrys sphegodes

Galanthus nivalis

Eranthis

Iris sibirica

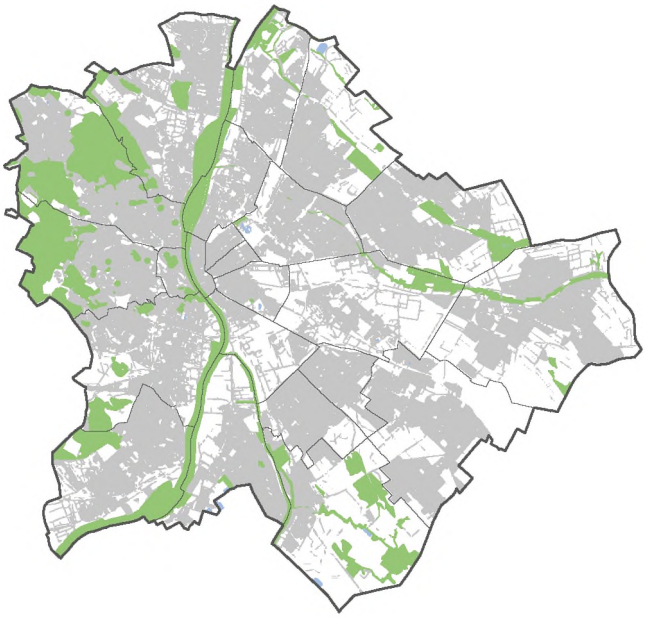
14 highly protected plant species

197 protected plant species

Every second plant species *found in Hungary can be found in Budapest.*

The preservation of its natural assets is a great challenge to the developing city, and therefore the remaining natural sites are usually protected by law at a number of levels: 7% of the total territory of Budapest, i.e. 3.671 ha are protected either nationally or locally. The *Natura 2000* sites of European significance stretch across similar areas and generally overlap with protected areas of national and local significance.

Nature conservation areas in Budapest



Buckthorn area (IV. dist.)

Apáthy-cliff (II. dist.)

Merzse-marsh (XVII. dist.)

Csillebérc (XII. dist.)

Gellért Bath

Budapest has the most thermal and medicinal wells: 110, 21-78 °C.

Gellért-Hill (Citadella) (235 m)

Nature Conservation Area, *Silene flavescens* occurs only here in Hungary.

The Danube bank panorama

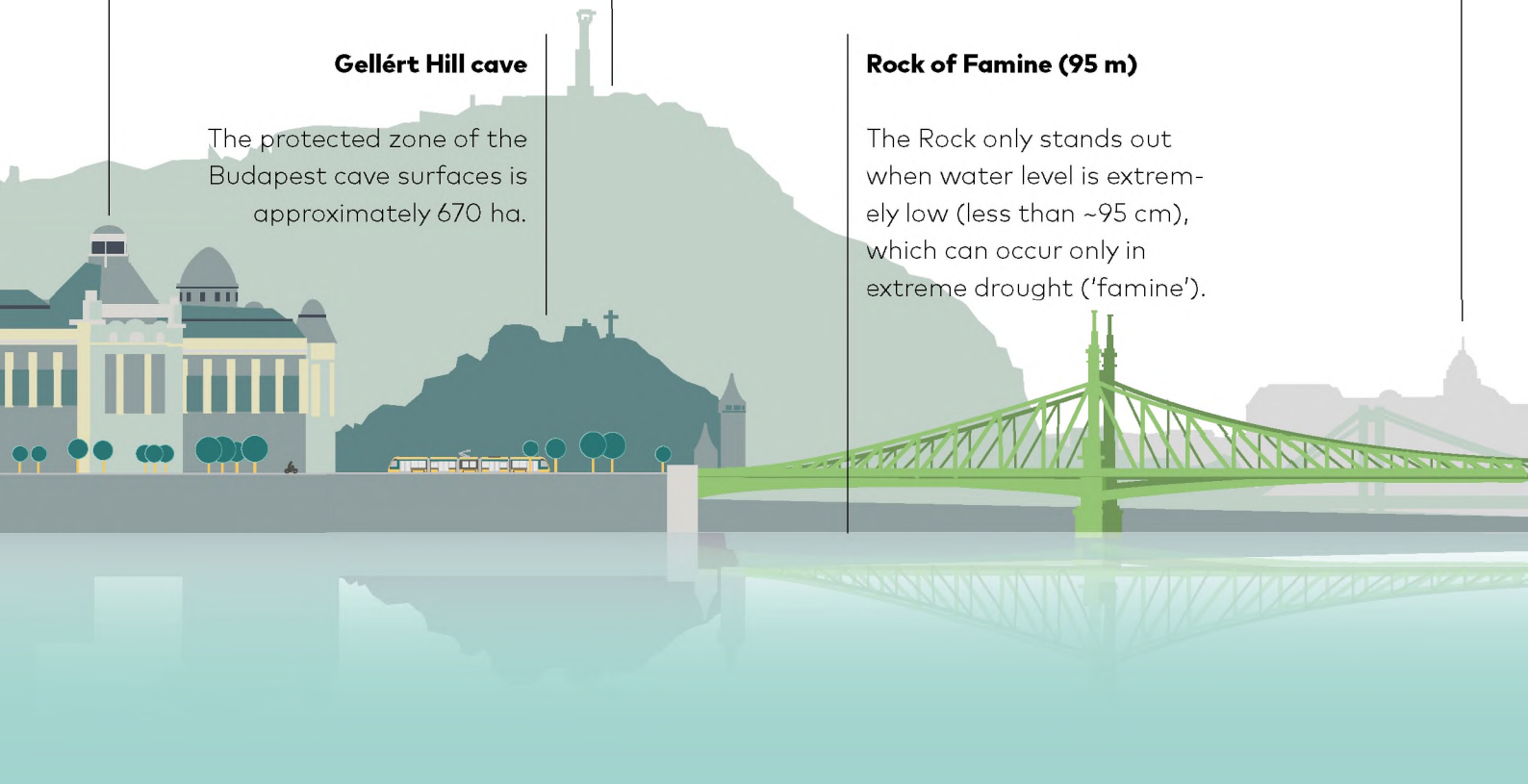
and Buda Castle district are part of the UNESCO Cultural World Heritage since 1987.

Gellért Hill cave

The protected zone of the Budapest cave surfaces is approximately 670 ha.

Rock of Famine (95 m)

The Rock only stands out when water level is extremely low (less than ~95 cm), which can occur only in extreme drought ('famine').



Green surface

The green surface system is a sub-system of a settlement described with specifically structured biological processes and ecological principles; it has an impact on the climate of the city, more specifically the humidity of the air, the thermal performance (urban heat islands), and the ground water conditions, quality of air, the biota and humans.

Compared to other European large cities of similar size, Budapest is moderately equipped with green surfaces for public benefits. On average there is approximately 53 m^2 green surface for public benefits (forest, public park, public garden, and sport and recreation area) for one person *(source: Urban Atlas)*. 2% of the territory of the capital city is covered by public parks and public gardens, which means that on average, 6 m^2 green area is available for one resident. Only 36% of the public parks and public gardens are managed by Budapest Municipality, the rest are typically maintained by the district municipalities. The forest coverage in Budapest is approximately 11% within the administrative borders, which is average in comparison to the reviewed European cities. More than two-thirds of the forest areas in the capital city (70%) are owned by the state and are managed by *Pilisi Parkerdő Zrt.*

Green areas per capita

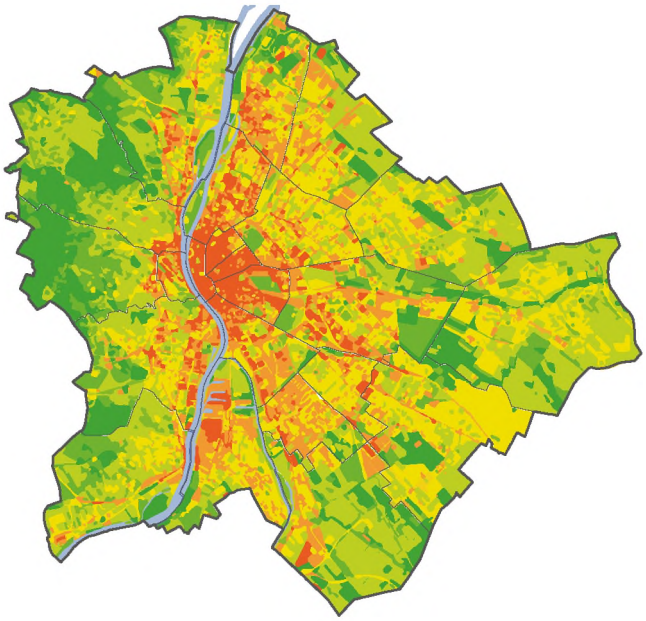
6 m^2 public green area

25 m^2 touristic forest area

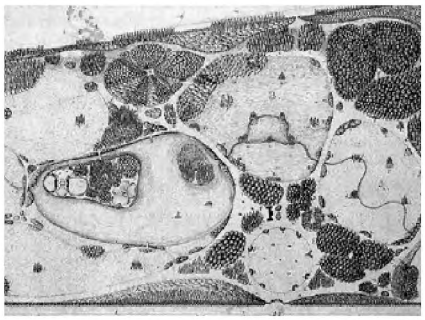
The average green surface intensity of Budapest was about 52% in the last 23 years. The green surface intensity expresses both the size of the area covered with plants and the vitality of the plants.

On the basis of the satellite pictures made since 1992, no significant changes can be detected but typical tendencies may be observed in certain areas such as reduction in the green surface intensity in economic areas, which is offset by the green surface intensity increase in brownfield areas.

Budapest green surface intensity, 2015



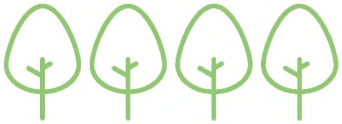
Variation of green surface intensity between 1992 and 2015



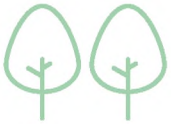
City Park

It is the world's first public park that may be visited freely and is also one of the most frequently visited parks in Budapest. Significant investment projects (mainly public institution developments) are in progress in the park. In addition, the full reconstruction of the park is also in progress as one of the largest green area development projects in the country.

in the forests



in private places



in public places

There are 7.3 million trees in Budapest according to the estimates, of which 4.3 are on planned forests and 2 million are in other non-public areas (generally in private properties). Approximately 1 million trees are in the public areas, of which 70% are managed by the district municipalities and 30% are managed by Budapest Municipality.

Budapest Municipality launched an extensive programme of planting trees over the past few years under the title of *"10.000 new trees for Budapest!"*. In the first instance of the programme, the *Főkert Nonprofit Zrt.* set targets of planting trees in the currently vacant tree positions and reconstructing the old alleys from 2018 according to a plan. At the end of the programme which already in place since 2016, Budapest got richer with 10.000 new planted trees by the end of 2019.

In order develop the green surfaces, the Budapest Municipality recently approved the *Budapest Green Infrastructure Concept*, which lays down the major green area development objectives and tasks. Besides the concept, there are numerous projects in progress for the development and quality improvement of green surfaces.

Size of public green areas per capita, 2012 (Source: Urban Atlas) m^2/person

Prague	*85*
Warsaw	*83*
Vienna	*73*
Paris	*65*
Budapest	***53***
Munich	*43*
Barcelona	*13*
Bucharest	*11*

Soil condition

Due to the extensive industrialisation in Budapest between the end of the 19th century and the change of the political system in 1989, there are brownfield areas and, as a consequence of environmentally polluting industrial and economic activities and uncontrolled waste dumping, contamination accumulated in the soil and ground water. The elimination of that contamination requires consistent efforts and a lot of resources, considering the geological and aqua-geological sensitivity of Budapest. The preservation of the world famous thermal water assets and the karst water base, extremely sensitive to contamination, is crucial.

Detailed exploration became necessary on more than 240 spots in the territory of the city since 1996; during that period, the required technical intervention was also successfully completed in more than 50% of the sites obliged for remediation. In total 129 remediation procedures were in progress in the administrative territory of Budapest in February 2019.

Remediation procedures in progress in Budapest, 2019 (Source: PMKH)

13% exploration

16% technical intervention

24% follow-up monitoring

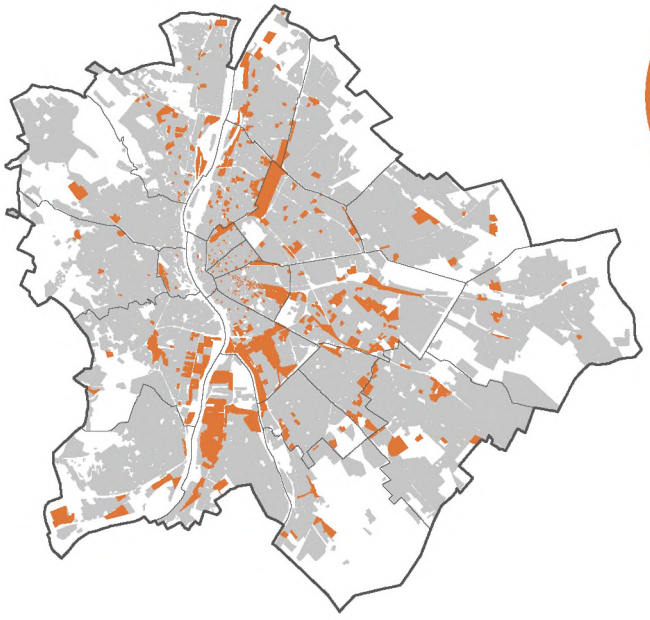
47% closed remediation

Remediation of the 'Metallochemia' brownfield area

The largest remediation investment of Budapest so far was completed 10 years ago around the factory site of the former non-ferrous metallurgy company, Metallochemia. The Nagytétény plant, which was active between 1910 and 1990, contaminated the soil of its area and sub-surface waters severely and was a threat to the health of the local residents. During the remediation of the 20 hectares of the plant and more than 1.000 residential properties in its vicinity, hundreds of thousands of cubic metres of blast-furnace slag and soil contaminated by heavy metal were extracted. Part of the polluting materials was deposited in a hermetically sealed sarcophagus, created as a green area, and the rest was used as filling in the M6 Motorway section crossing the plant in north-south direction.

The industrial companies, originally established in suburban parts, are now brownfield sites surrounded by residential areas. At the moment, there are at least 1.200 ha brownfield areas in Budapest where the previous functions have been abandoned or insufficiently used and their recovery requires intervention.

The Budapest Municipality defined the brownfield areas as urban development target sites in its long-term development concept, which provides an alternative to greenfield investment. In line with this objective, the *Brownfield site development Thematic Development Programme* was adopted, creating a single framework for the development efforts aimed at the restructuring of those sites.
Budapest Municipality has prepared a register of brownfield sites, containing the urban architecture features of each site, the information under potential sale, as well as the downtown properties not in use (empty plots, vacant building) covering in total approximately 3.000 hectares.



3.000 ha
brownfield and underutilized area

Air quality

Air pollution is one of the major environmental problems of Budapest. It has a harmful effect on the health of the population, on the natural environment and also has impacts on the climate change. The air quality in Budapest is influenced primarily by the emissions of domestic heating and from transport.

In line with the national and European trends, over the last decades there has been a major decline in the volume of air pollutants of industrial origin (sulphur dioxide, carbon monoxide, nitrogen oxides and solid particles). At the moment, the air quality in Budapest is significantly better than it was 50-60 years ago, when the annual sulphur dioxide level in Budapest was 3-4 times the current limit value.

Air pollution measurement in Budapest

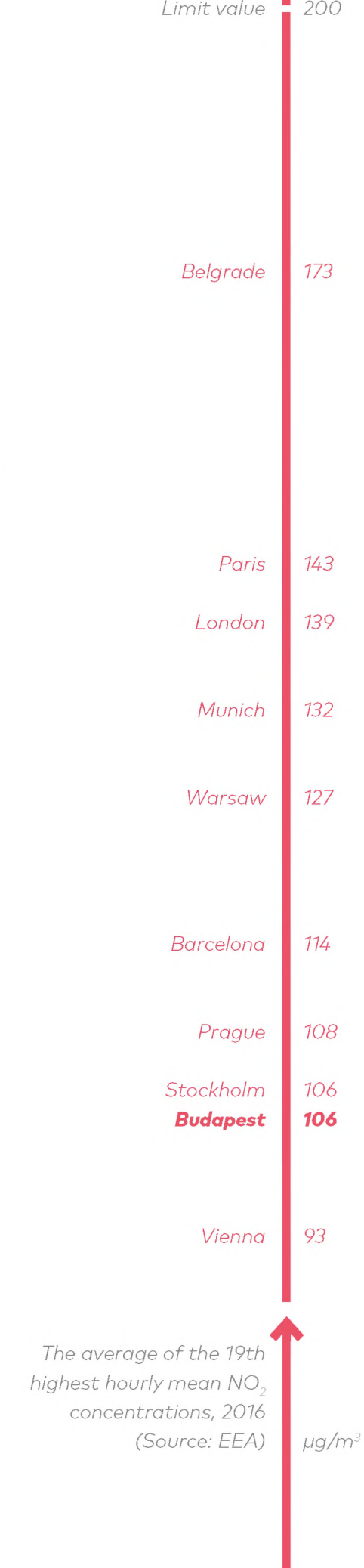
The first air pollution measurements in Budapest were conducted a long time ago, in 1929 and automated measurements began in 1974, the results of which are also comparable with the current measuring results. 12 measuring stations supply air quality data regularly.

In a European comparison, and based on the data published by *European Environment Agency* (EEA), PM_{10} (particulate matter), nitrogen dioxide and ground-level ozone pollution in Budapest is average. Nonetheless, in the past ten years the nitrogen dioxide (NO_2), the PM_{10} (particulate matter) and its benz(a)-pyrene (BaP) content in Budapest are still regularly higher than the EU limit values. Occasional the enrichment of the ground-level ozone puts an extraordinary load on air quality. With regard to the other air pollutants (sulfur dioxide, carbon monoxide and benzene), there is no problem at all or the problems are negligible – the Hungarian authorities classified the air of Budapest as excellent for these substances.

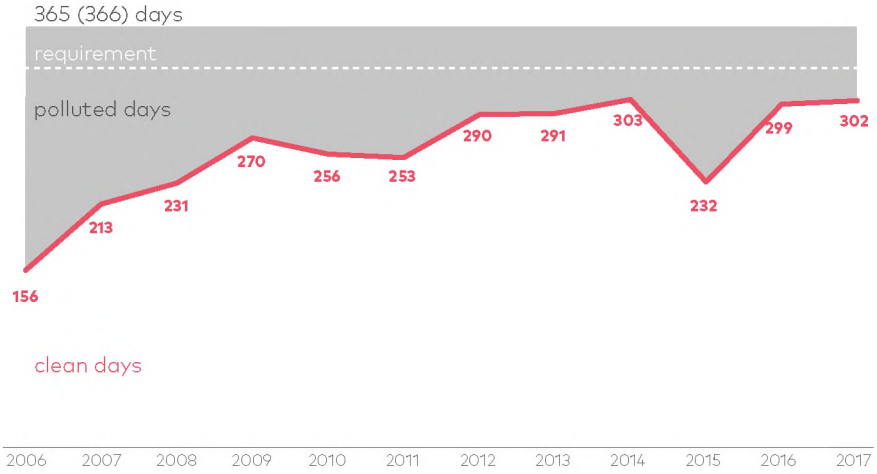
The PM_{10} is directly emitted (in the order of significance) by the heating of households and institutions (primarily solid biomass combustion), followed by road transport (soot, dust, particles from road use), industrial production and agriculture. The fine particulate matter ($PM_{2.5}$) is most harmful to health, because at the moment there is no identifiable threshold below which it would not pose a risk. The *National Public Health Center* estimates that the level of $PM_{2.5}$ in Budapest is responsible for about 3-7 percent of deaths before age 30. If the annual average value of $PM_{2.5}$ (21 µg/m^3) measured in 2017 at the Budapest city background measurement station *(Kőrakás park)* is considered to be valid for the whole area of Budapest, then reducing this level to the WHO recommended limit (10 µg/m^3) could have prevented 1.334 premature deaths, which is 6.4% of all deaths in Budapest that year.

The health status of the population in Hungary is mainly determined by smoking, hypertension, dietary risk or high body mass index, air pollution was the eighth factor in 2017. The impact of air pollution is more significant in children, because many of the additional factors are not typical in this age group.

The high nitrogen dioxide level is primarily associated with the emission in road transport, it is followed by the contribution of power generation and household heating.



61,4 *Belgrade*



53,6 *Warsaw*

Rate of PM_{10} clean days in the year, 2006-2017 – when 24 hour result of every monitoring station in Budapest was below the limit (50 nq/m³)

50,0 *Limit value*

49,2 *Budapest*

The ground-level ozone pollution is the result of complex and complicated processes. It may be associated with urban nitrogen oxide emission but it also requires high intensity solar radiation and high daily mean temperature. Over the past ten years the notification degree of a smog alert had to be announced twice due to the ozone level but given the unfavourable projections about climate change in future the situation may further deteriorate.

41,2 *Paris*

39,9 *Prague*

37,9 *Stockholm*

36,9 *London*

In winter, from time to time, must announce a smog alert due to high PM_{10} pollution. During a smog alert not only the population is notified but, the road traffic can be also restricted: in critical situations, vehicles that are harmful to the environment are banned from the city transport. Budapest Municipality adopted a decision on further restrictions recently, in case of smog alert: by 2019 other vehicle categories (two or three-wheel motor vehicles without registration numbers and Euro3 and 4 diesel vehicles) were added to the 'black list' in phases, so practically every second vehicle will be affected by the restriction during a smog alert.

35.0 *Vienna*

34,9 *Barcelona*

It is also important to note that on the basis of the latest research results, 80-90% of the events resulting in a PM pollution level that triggers an alert is the result of special meteorological conditions and that they end when the meteorological conditions change significantly.

32,6 *Munich*

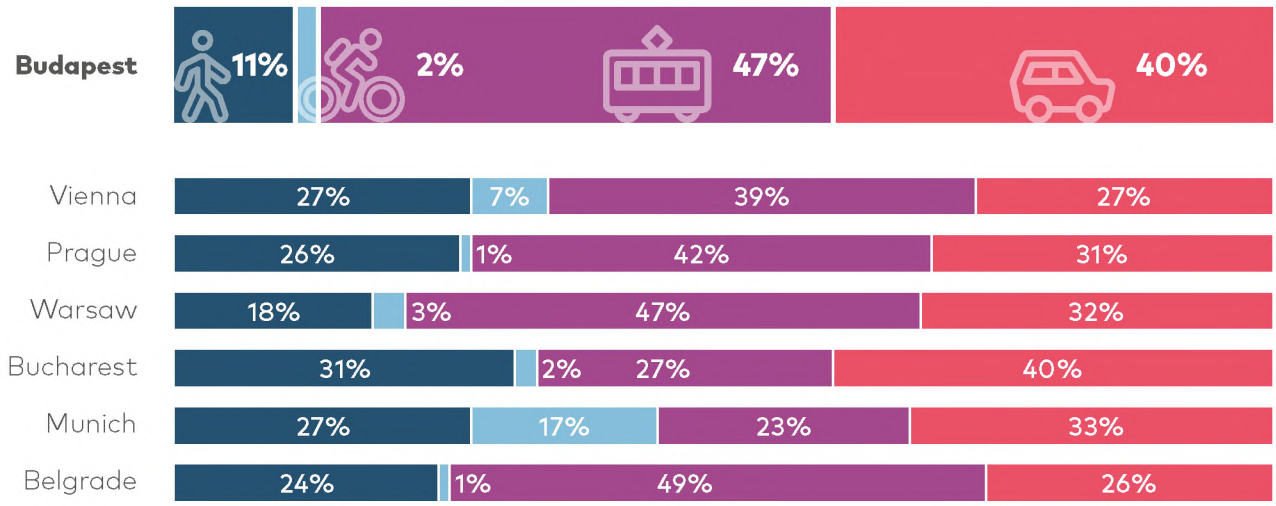
Most projects aimed at improving the quality of air focus on energy management and urban transport. Bearing that in mind, the Municipality of Budapest concentrates strongly on promoting environmental mobility and district heat supply.

The average of the 36th highest daily mean PM_{10} concentrations, 2016 (Source: EEA)

µg/m³

Transport

In terms of energy consumption in Budapest, transport is the second dominant factor as the combustion of petrol and diesel oil in transport makes up 17% in the CO_2 emission of the city. The role of transport is the major factor in the two most critical environmental problems of the city: it is a fundamental factor in noise and vibration pollution and it also has a significant impact on the quality of air, i.e., it influences a great deal the liveability in the city.

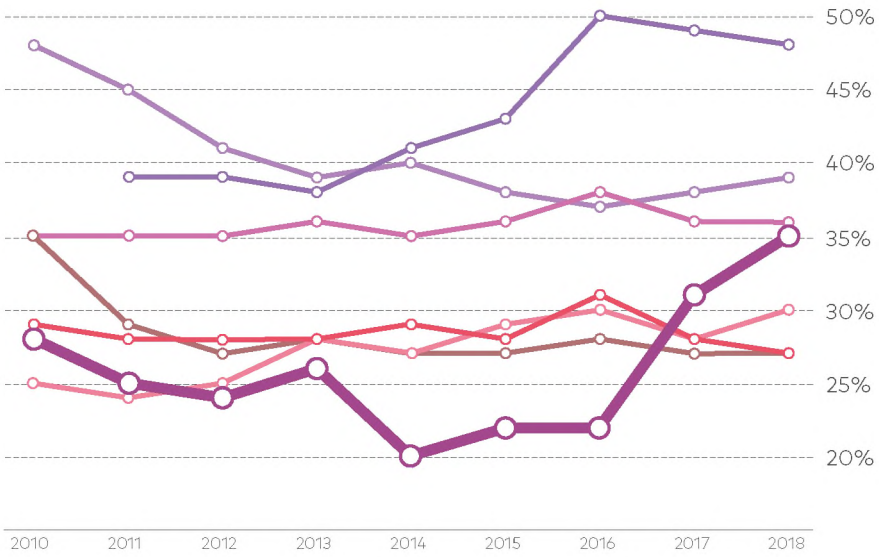


Modal split in Budapest and in international comparison

Shares of the transport modes in Budapest: public transport 47%, passenger car driver 34%, passenger car passenger 6%, pedestrian 11%, cycling 2%. In comparison with the surveyed European cities, the ratio of people using passenger cars is high in Budapest.
Within public transport, the environmentally-friendly track-bound transport (tram, cog-wheel railway, trolley bus, suburban train, subway, underground railway, funicular, cable car) represents approximately 55% in passenger kilometres.

There was no relevant change in the traffic impact on the road network of Budapest between 2007 and 2017 (the volume of traffic grew only by 1.5-2.0% depending on the economic situation). In that period, the vehicle stock continued to age. The average age of vehicles in Budapest is 12.2 years, which is more favourable than the national average. There is intensive two-way traffic between Budapest and the agglomeration which, without transit traffic, include 600.000 passengers in passenger cars and 350.000 passengers using public transport. In order to reduce commuting with passenger cars Budapest intends to promote the model switch and the construction of P+R parks.

Changes in the congestion index of European cities of similar characteristics in 2010-2018 (Source: TOMTOM)



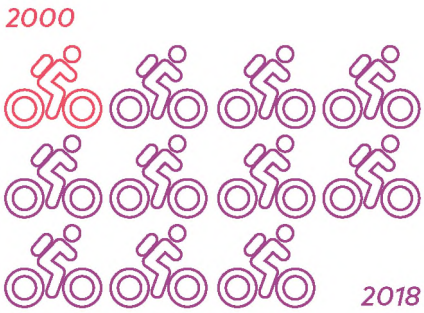
The shortage of parking spaces and the environmental impact of the traffic in search of parking and congestion are a problem in downtown. The congestion index shows how much longer the total travel time compared to the free flow of traffic. Budapest is moderately congested and was in 23st place among 60 European cities in 2018.

In Budapest the petrol and diesel fuelled vehicles dominate, and the vehicles running on alternative fuel do not represent even 1% of the total stock. The number of vehicles with "green registration numbers" (environmental category 5, purely gas or electric or hybrid vehicles) increased by 5-10% between 2013 and 2015, their number was almost 10.000 in Hungary in December of 2018.

At the moment, there are almost 200 electric recharging points in Budapest but the electric recharge infrastructure is gradually expanding. They can be used free of charge and vehicles carrying green registration numbers can still park free of charge in all parking.

The size of air traffic is also growing both in terms of the number of passengers and planes. The growth rate is still higher than the European Union average but has not yet caught up with the size of air traffic in large cities of the region (Prague, Warsaw). Cargo traffic is growing even more intensively than passenger traffic.

During the past 20 years, cycling traffic increased by approximately ten times in the inner parts of Budapest and less in external areas. In 2010, the total length of cycling path in Budapest was 209 km, which grew to 317 km by the end of 2018 reflecting 52% increase. Approximately 1.900 km may also be considered cycling-friendly on lower category roads not marked for cycling.



The development of public transport involved the construction of metro line 4 and the vehicle development project of BKV, under that 47 trams and 36 trolleies were put into circulation by December 2017. The expansion of the cycling infrastructure and the introduction of the *MOL Bubi* public bike system with its 127 collection points and 1.546 bikes in the downtown area and continuously expanded also towards external districts have contributed a further reduction in emission. In addition, the public rental services are also growing constantly, where mostly electric vehicles are offered for use. Hopefully, in the future only electric vehicles will be available for hire.
The eastern sector of M0 motorway, the M6 motorway and *Megyeri Bridge* were constructed in order to reduce car traffic in the city, too.

The Budapest tram network at the forefront of the world

The first tramline of Budapest was opened in 1889 between Nyugati railway station and Király utca. The tram network in Budapest is now one of the basic components of public transport and is the world leader based on the number of passengers (396 million persons/year). The tramline No.4 and 6 on Nagykörút is one of the busiest tramlines of the Europe, used by almost 200.000 people every day. The 55.9 m long CAF Urbos 3 trams operating on tramline No.1 are the longest trams in the world. Tramline No.2 on the Danube bank is one of the ten most beautiful tramlines in the world.

Noise pollution

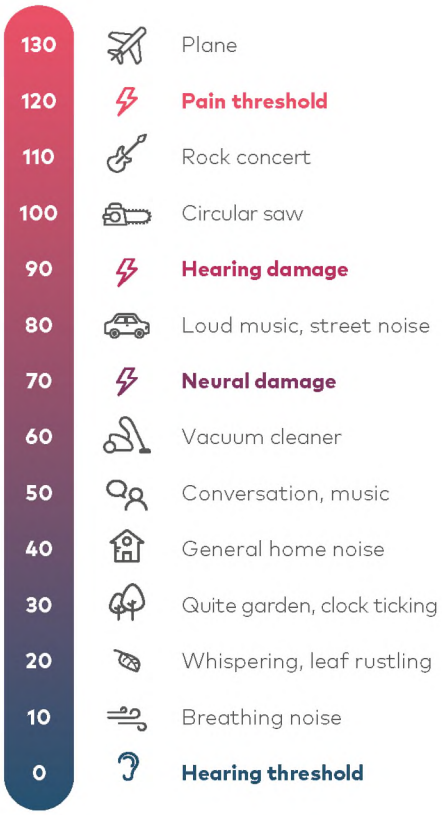
One of the most important environmental problems in Budapest is the high noise impact, which has a harmful effect on the well-being, quality of life and health of the people.

The primary source of the noise in Budapest is road transport. The noise load set for the whole day (L_{den}) near some main routes is 12-17 dB higher than the applicable threshold. Besides road traffic, the noise pollution caused by air traffic is also increasing. Complaints occur across the whole town because of the rapidly increasing air traffic and changes in the regulations of the use of the air space.

The strategic noise map of Budapest

The new strategic noise map of Budapest was complete in 2017, on which the noise nuisance trend can be analyse in 10 years' time. The General Assembly of the Municipality of Budapest approved the new noise-reducing action plan based on the new assessment.

Road noise pollution during the day, 2018



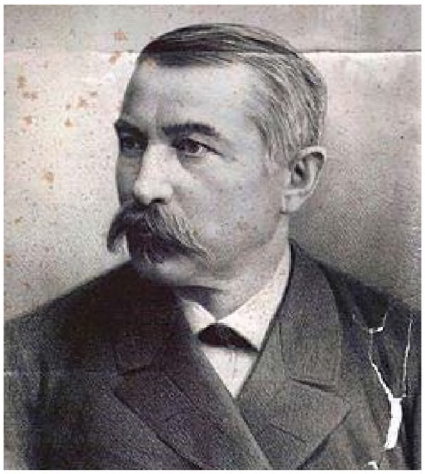
In Budapest approximately 27% of the population is exposed to more than 65 dB (L_{den}) noise level, which may cause harm to health. The significantly high noise level at night has almost similar rate as during the day. In comparison to other reviewed European cities, the population of Budapest is exposed to higher than average noise level.

In the past decade a number of noise reduction measures were taken that had favourable impact on high population density areas. As a result of the constructed northern section of the M0 motorway ending at *Megyeri Road* the transit traffic decreased significantly on the busy internal routes. Primarily, the heavy goods vehicles that cause a lot of noise pollution avoid the city centre. Other major investments were made into construction of noise reduction barriers and into the development of public transport (handover of M4 metro, construction of low vibration tracks on the tramlines, procurement of advanced vehicle stock), which has also reduced noise pollution in the areas mostly affected by noise.

The strategic noise map may function as an effective instrument in mitigating noise pollution and the reduction of the impact (especially in relation to any change in the traffic rules, road reconstruction or new construction projects).

Waters

Fresh water is one of the greatest and unfortunately increasingly diminishing assets of the Earth. Hungary is in the lucky situation to possess extremely good quality and large amounts of fresh water reserves. Budapest is especially abundant in medicinal and thermal waters. It is a challenge that the majority of the fresh water reserve of the country comes from over the borders (only 5% of the water assets originate in Hungary) and therefore the water base is rather vulnerable. At the moment, the majority of our water stock flows through the country without utilisation. It is a challenge for the future to preserve the quality of waters and to use them locally providing adequate protection consistent with the increasing risks of contamination.



János Wein

In Budapest the institutional planning and construction of water supply began under the control of János Wein in 1873. The initial period of drinking water supply witnessed professional disputes lasting for decades, finally the natural, bank-filtered drinking water supply system based on the water base of the Danube, for which Wein also argued firmly, was developed. This turned out to be a good decision in the long term in the respect of water supply capacity and the quality of the produced water because even now drinking water is supplied to consumers on the basis of the same principles, following a number of technical and technology steps.

In the case of Budapest, the security of drinking water supply based on the *River Danube* and the natural bank filtering capacity is essential. The quality of the supplied drinking water is regularly checked in an accredited laboratory. The quality of the supplied drinking water complies with the requirements with respect to each examined parameter. Spas and thermal waters are also among the natural assets of Budapest. In Budapest, 113 cold water wells and 59 thermal wells operate, which attend 14 thermal water and medicinal water based spas, as well as other karst water and mineral water based baths.

In international comparison, Hungary is among the five countries richest in thermal water: after Japan, Iceland, Italy and France, Hungary is the 5th largest thermal water power in the world. Of the 220 recognised thermal waters existing in Hungary, 16 are in Budapest and 19 of the 224 mineral waters are also in Budapest.

On average, approximately half a million m^3 wastewater is generated in Budapest each day. The wastewater treatment procedures of the city have developed significantly in the past decades: With the help of the third and highest capacity *Budapest Central Wastewater Treatment Plant* commissioned in 2009, these days almost 100% of the wastewater generated in Budapest is led into the River Danube after full biological treatment, instead of only 50%. As a result of the major developments of the recent years, the degree of sewer supply in Budapest has reached almost 100% (more than 99% of the properties are connected to the sewer system).

The above mentioned wastewater treatment results also have a positive impact on the surface waters. The analysis of the 2009-2017 period revealed that, apart from a few parameters, the quality of water in the River Danube complies with the limit values specified by law. However, the quality of the small water flows and the *Ráckevei (Soroksári)–Duna* branch still does not meet the requirements.

In the recent years, demand has increased for revitalisation, which also improved the quality of water of the small urban water courses as the areas of a complex recreational green corridor and city habitat. Preparations began for the revitalisation of *Rákos Stream* and its surrounding area with a feasibility study plan and a master plan, containing the visions for the recovery and transformation of the areas along the stream. Budapest Municipality developed study plans also for the areas around *Szilas Stream* and *Ráckevei (Soroksári)–Danube branch*, too.

Paris 187

Belgrade 151

Bucharest 148
Stockholm 148

Vienna 130

Budapest **129**

Munich 128

Barcelona 127
Warsaw 127

Prague 108

Household drinking water consumption *l/person /day*

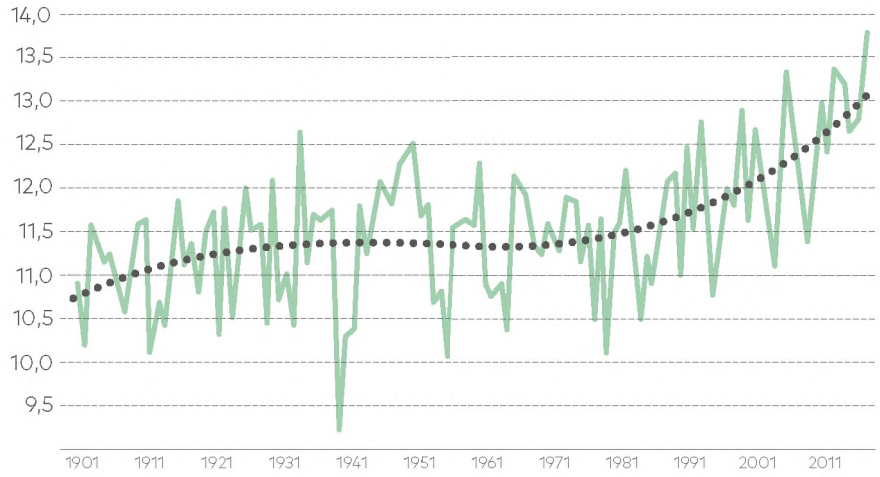
Climate protection

The climate change is one of the greatest challenges of our days. Everyone must take responsibility for the rapid changes as the demands of the advanced consumer society entails a great deal of greenhouse gas (primarly CO_2) emission. The larger cities face especially great challenges because the negative climate effects are multiplied in a city climate. The climate change has an effect on health, the natural and built environment and therefore besides the reduction of emission and the prevention of effects, a great deal of attention must be devoted to the adaptation to the impacts that have already occurred.

3-4 °C average temperature increase *is expected in Hungary until 2100*

The global climate change is also clearly reflected in the climate conditions of Budapest and the residents can also feel it. Between 1901 and 2018, the annual mean temperature of Budapest rose by 1 °C over 117 years. Simultaneously, the total annual volume of sunshine has been risingalso. The increase in irradiation gives a further boost to the residents' heat sensation.

In addition, the frequency of extreme weather events is also rising. In the recent decades there have been more frequent heat waves. The number of deaths increases significantly on the days of the heat waves. On such days the number of death is up by 15-20% in Budapest.

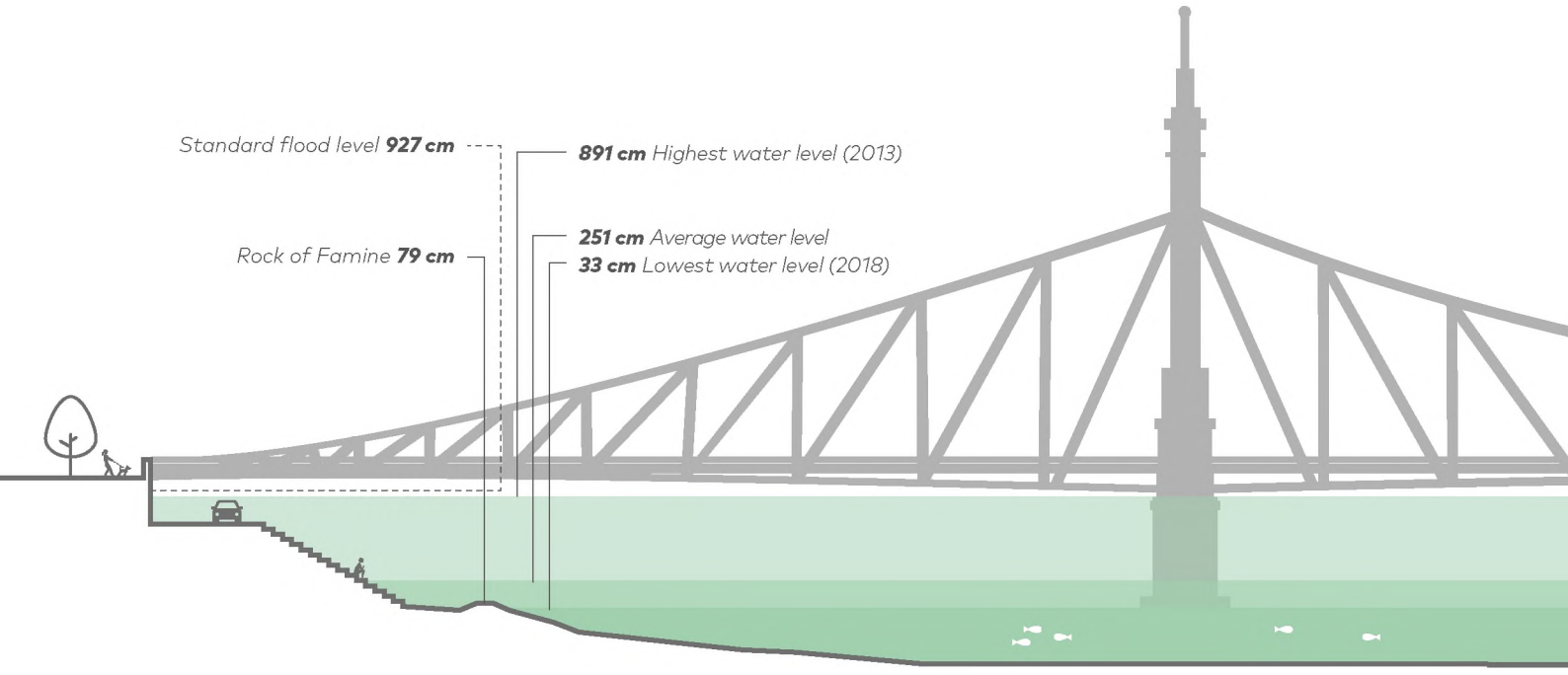


Changes in the annual mean temperature in Budapest between 1901 and 2018 (°C) (Source: OMSZ)

The more frequent rainy days with sudden large quantities of rainfall also cause further damages. On such days the sewer network of the city overloads and water flows in the streets, paralysing traffic.

In relation to the climate change flood risk represents one of the most important challenges. As a result of the extreme precipitation, floods are also becoming increasingly extreme. In addition, the changes in the use of flood-plains ways (increase of the built-on areas) adds to the flood risk but finding a solution to that problem is beyond the facility of the municipality (as it requires state intervention and international cooperation).

Over the past few years the Danube flood levels approached and even exceeded the previously registered highest flood level without ice (2002, 2006, 2010 and 2013), which indicates more frequent occurrence of extreme weather conditions. According to the experience gained during the extraordinary floods after 2002 and the related surveys, the flood protection structures are not high enough, their structure and cross section requires development at many places. The required interventions are being prepared.



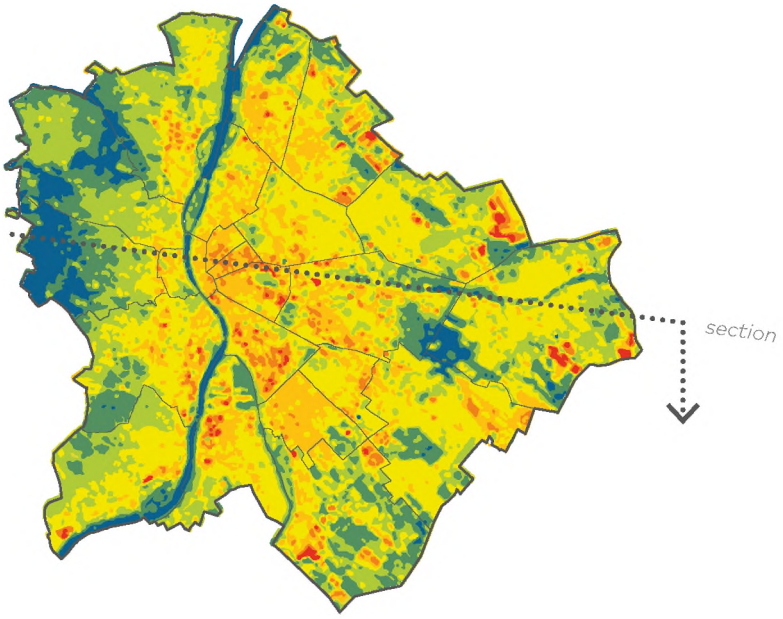
The 'great flood' of Pest

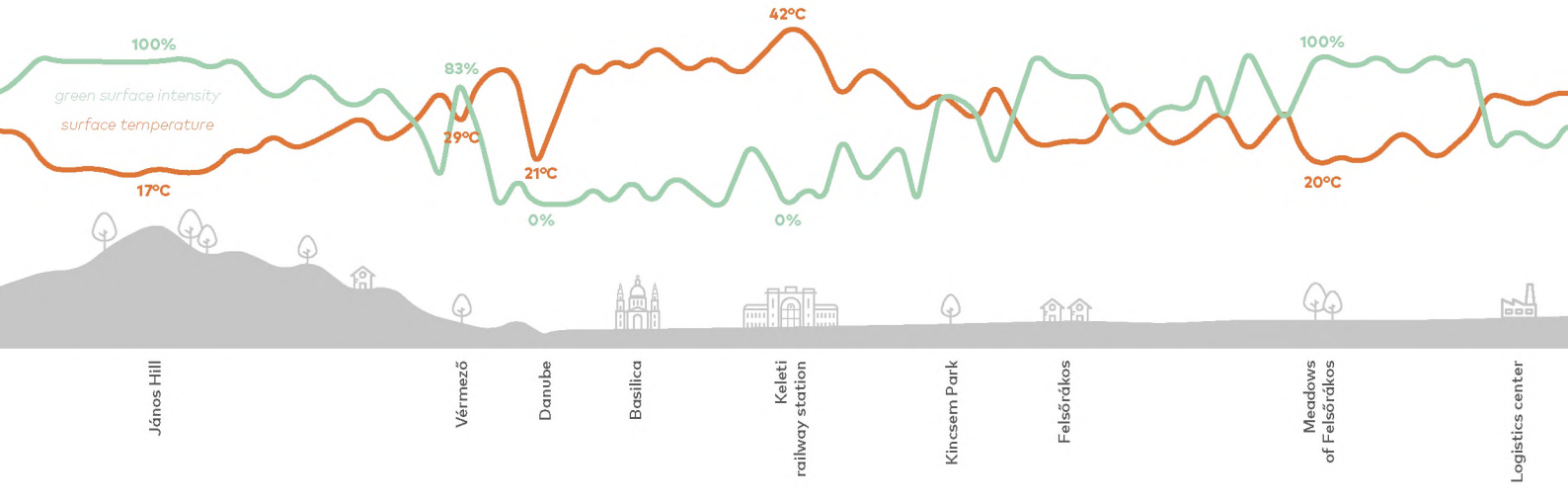
During the 1838 icy flood, the water broke through the barriers due to the large volume of precipitation and melting snow and the ice plugs forming in the southern part of the city further increased the water level. The icy flood had devastating effects on the city. It is described by Baron Miklós Wesselényi, the 'flood hero on boat' saving lives as follows: "...houses also began to break and fall. The ripping noise and the speed, the dust clouds emerging from the water, the frightened screams, cries and shouting presented an awful picture of this storming decay." More than 50.000 people lost their homes in the flood and 151 people died. A decision was made to build the embankments after the flood.

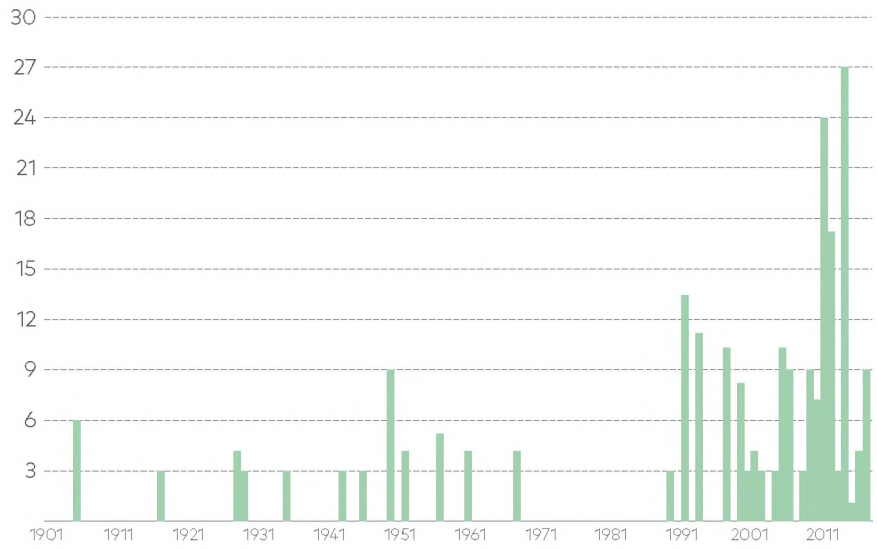
The extensive urban heat island also adds to the impacts of climate change in Budapest: in the summer period the temperature in the densely populated areas is 4-6 °C higher than in the external areas containing large green surfaces. At particular moments, the differences can be even greater. The heat map also shows that compared to the 15-25 °C surface temperature of forests the typical temperature in the city centre is 35-40 °C. The intensity of the Budapest heat island is average among the reviewed European large cities.

Budapest surface temperature on 31 August 2016

45 °C felett
40-45 °C
35-40 °C
30-35 °C
25-30 °C
20-25 °C
15-20 °C







Number of days with at least 27 °C daily mean temperature heat waves lasting for at least 3 days in the urban area of Budapest between 1901 and 2018, based on homogenised data (Source: OMSZ)

According to some research the annual mean temperature of the country will rise by 1-2 °C in the near future (by 2050). The number of frost days will decrease by 18, while the number of hot and extremely hot days will rise by 12. Only a small decrease is projected in the volume of annual precipitation, but the length of dry periods will be significantly longer. However, the extreme precipitation events will become more frequent, especially in autumn and winter.

Budapest Municipality has already taken major steps to reduce the emission. But no complex development has yet taken place in the adaptation to climate change. Nevertheless, developments are in progress in certain areas, such as flood protection. The recently approved climate strategy of the city defines specific objectives and measures for the adaptation. The concept of adaptation is unknown to the population and therefore a different mind-set will have to be formed, in which the non-governmental organisations and the public utility companies of Budapest play an important role.

Bucharest	*2,9*
Milan	*2,7*
Belgrade	*2,6*
Warsaw	*2,3*
Budapest	***2,2***
Vienna	*1,9*
Munich	*1,8*

Annual average surface temperature based heat island intensity in the evening hours between 2001 and 2005 (Source: Pongrácz-Bartholy-Dezső)

°C

Energy management

One of the most decisive factors affecting the environmental condition of a town is energy management. The degree of energy consumption is affected by the number of population as well as the development of the economy. The volume of emission from energy consumption is determined mostly by the composition of the used energy sources. Consequently, Budapest must take major steps to reduce its emission despite the external factors.

On the basis of the assessment of the main end user groups of fuels, the energy consumption of the population of Budapest is estimated at 40-50%. On the basis of the end consumption in Budapest in 2017 (about 31 million MWh), it can be concluded that the energy consumption by resident is 18 MWh/person.

Energy management of Budapest

85% fossil energy
11% nuclear energy
4% renewable energy

The majority of CO_2 emission of Budapest comes from the energy consumption of residential buildings. That is caused by a great deal of fossil fuels as well as the bad energy status of residential buildings. In this respect, Budapest faces a difficulty: there are many historic monument buildings in the capital city, where energy efficiency improvement options are limited. The other sector with high greenhouse gas emission is transport – this is not about emissions of the main air pollutants (e.g. NO_2 and $PM_{2.5}$). It is a challenge for Budapest that the capital city is the centre of the radial transport network of the country with significant transit traffic. The growing average age of the vehicles is another problem. However, the emission of large industry facilities is not high because the industrial structure of the city has been transformed from the 1990ies and heavy industry has been reduced.

As a result of the CO_2 emission related to the energy consumption of Budapest in 2017 (9.5 million tonnes CO_2 equivalent emission), 5.4 t CO_2 relates to one resident, which is favourable in international comparison.

CO_2 emission from energy consumption in Budapest, 2017

7% natural gas consumption of service buildings
44% electricity generation
9% district heat generation
18% natural gas consumption of residential houses
18% petrol and diesel oil

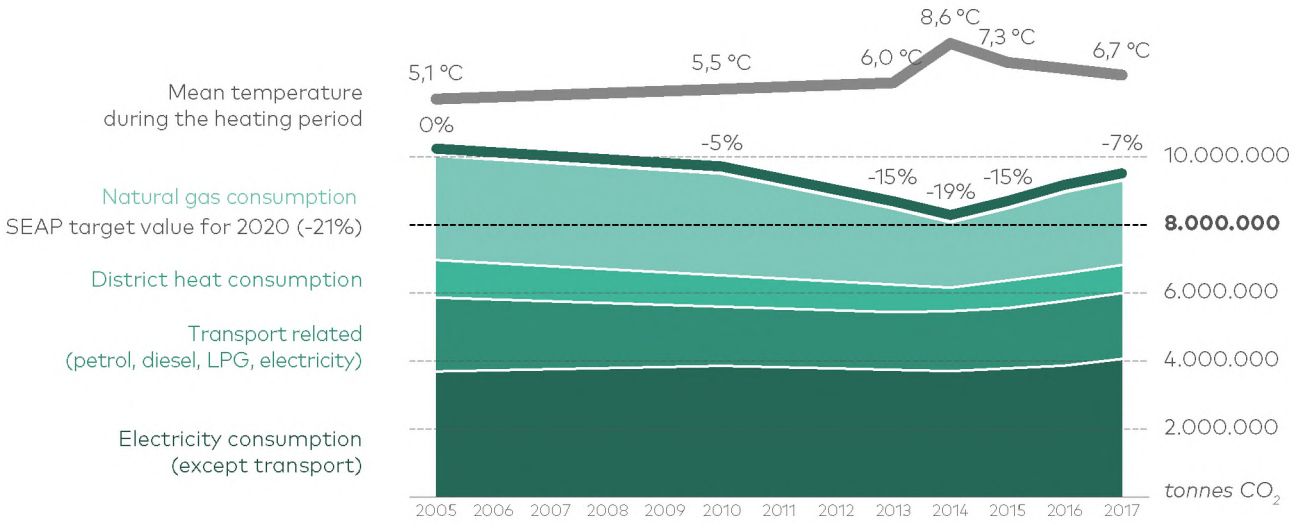
The Municipality of Budapest joined the *Covenant of Mayors* in 2008. In that process it prepared a *Sustainable Energy Action Programme* (SEAP) for Budapest, in which Budapest set a target of reducing CO_2 emission by at least 21% by 2020 (based on the 2017 annual data the current CO_2 emission reflects approximately 7% reduction).

The CO_2 emission inventory has shown a reduction since 2005, but the tendency has changed in the recent years. The volume of CO_2 emission is influenced by a number of economic and social, environmental (primarily weather) factors. The emission reduction observed during the economic crisis resulted from lower energy consumption, while in the recent years the economy was growing and gas was used more intensively during the colder period requiring heating.

In order to adapt to the impacts of the climate change, reduce the greenhouse gas emission and in order to facilitate the related mind set development, Budapest prepared its climate strategy in 2018.

A number of sustainable energy management projects were implemented in Budapest over the past ten years. Most building energy projects involved heating modernisation, heat insulation and the use of renewable energy sources. Solar and heat pump systems are spreading gradually in the private sector.

Good examples in public institutions include the *Budapest Thermal Project* implemented in 2011, as a result of which the waste heat of *Széchenyi Thermal Bath* is used for the heat and hot water supply of *Budapest Zoo and Botanical Garden*. The expansion and interconnection of heat districts are ongoing in relation to the district heat network bythe establishment of backbone pipes. A project was also implemented for the utilisation of the landfill gas generated in *Pusztazámor Waste management Centre* (the recipient of the waste generated in Budapest). Lighting modernisation projects were also completed at the cost of HUF 3.5 billion aimed at higher energy efficiency of public lighting and traffic lights.

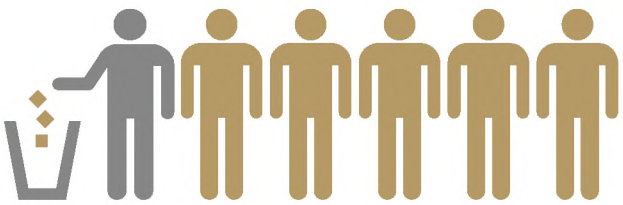


Changes in CO_2 emission relating to energy consumption since the base figures in 2005

Waste management

Waste management is closely related to material used, i.e. resource management. We face serious problems both globally and nationally, as the excessive use of resources is becoming more frequent. At the moment, mankind uses as much resources a year as generated by the Earth in one and a half years and produces so much waste that can no longer be coped with. The accumulated waste entails significant environmental and ecological risks.

On average approximately 1.3-1.6 million tonnes of waste is generated in Budapest each year, making up approximately 10% of the waste generated in Hungary. The waste management utility *(FKF Zrt.)* collects approximately 600-650.000 tonnes of municipal waste per year. The per capita municipal waste in Budapest is 350-400 kg/person, which is lower than the EU28 average 480 kg/person).



An average weight* resident of Budapest produces garbage equal to five times than its weight each year

**women: 69 kg, men: 83 kg*
(Source: KSH, 2018)

55,4 *Ljubljana*

29,2 *Vienna*

21,5 *Stockholm*

14,3 *Prague*

11,6 *Paris*

7,6 *Budapest*

4,5 *Warsaw*

2,9 *Bucharest*

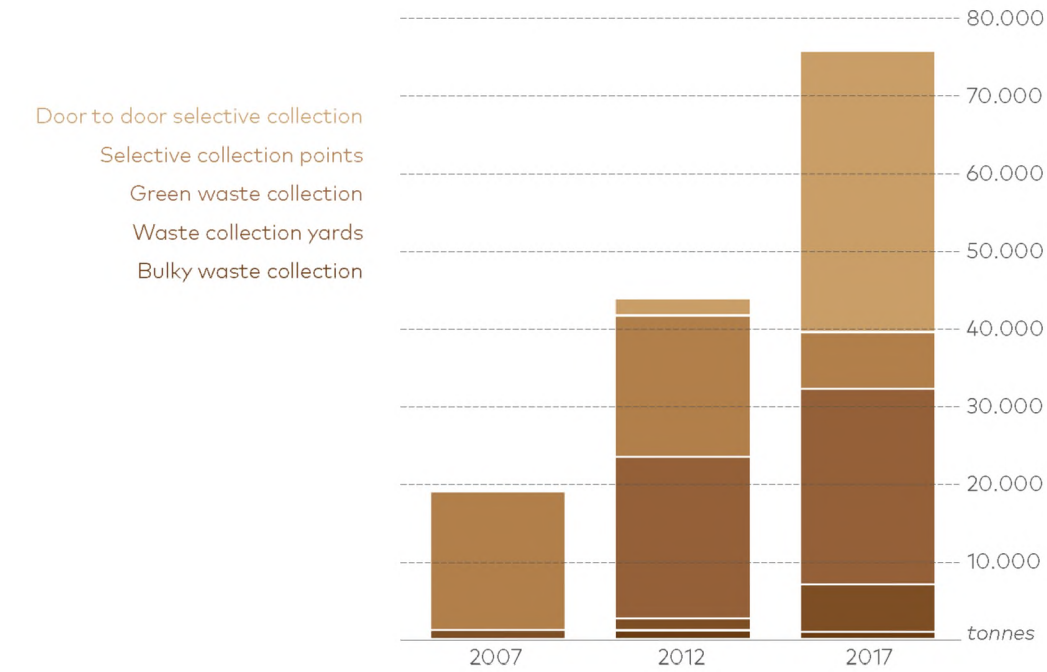
Ratio of selective collection of paper, metal, glass, plastic and bio waste in some capital cities of the EU, 2014

%

Among the municipal waste management tasks one of the greatest challenge is to recover as much materials as possible for recycling. In the past few years, the residential selective waste collection system developed significantly, at the moment, FKF offers the following selective collection options to the residents:

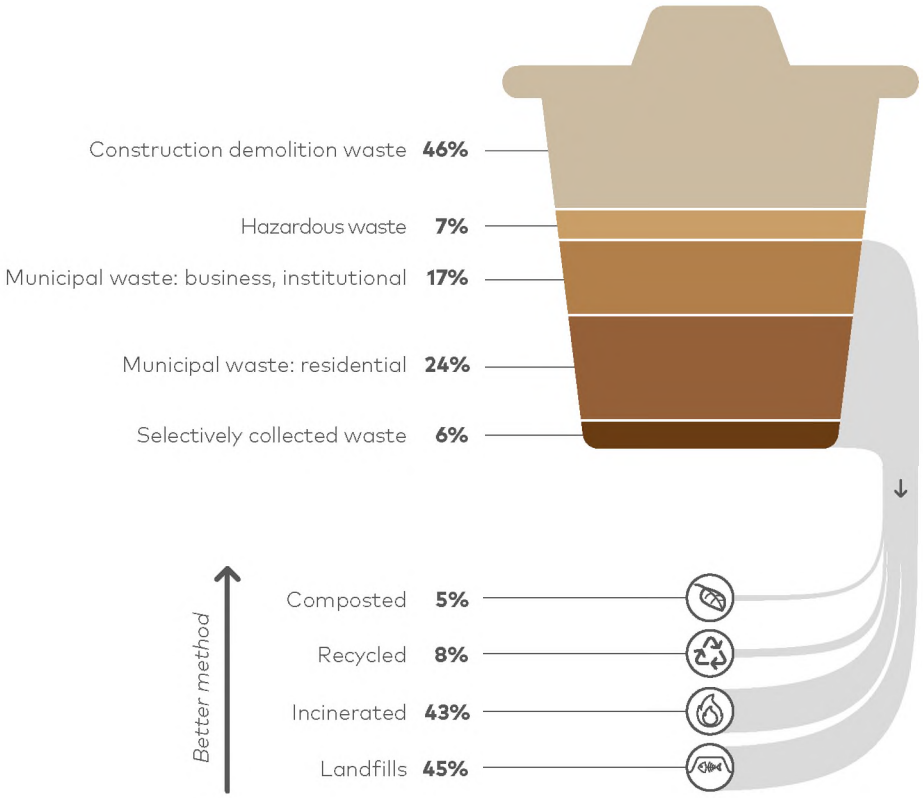
- *door to door selective waste collection system:* weekly collection of paper, plastic and metal waste (the total coverage includes approximately 403.000 waste bins), collection of green waste from the middle of March to end of November (in suburban residential areas); bulky waste and residential hazardous waste collection once a year.
- *selective waste collection points:* glass, paper, plastic and metal waste collection (140 collection points + 111 glass collection points);
- *waste collection yards:* selective waste, residential hazardous waste collection (17 yards);

In 2016 the volume of selectively collected waste was growing 10% of the total waste compared to the all collected waste by the framework of public services), however, that ratio is still lower than measured in other large European cities comparable to Budapest.



Volume of waste collected separately in Budapest within the framework of a public service (Source: FKF)

Budapest also lags behind other cities in terms of the treatment of the waste generated within the city: although the ratio of energy recovery is relatively high, the volume of waste disposed in landfills is very high and the ratio of recycling is very low.



Generated wastes in Budapest, 2017 (Source: FKF)

Municipal waste treated by FKF according to the treatment methods (recovery and disposal), 2017 (Source: FKF)

Summary

Budapest went through significant development over the past ten years and further significant development is still ahead. Concerning the status of the environment, the most favourable processes can be observed in transport. The development of public transport and other environmentally-friendly modes of transport offsets the unfavourable processes of motorisation and demographic changes. In addition, the city has made major progress in waste management (door to door selective waste collection system) and energy management (energy efficiency projects in public services).

At the same time, among the environmental problems described in detail in the publication, the following continue to be important. Budapest Municipality as well as all other affected actors must continue to pay outstanding attention and allocate financial resources as well to the management and resolution of those problems.

- Noise load generated by traffic is high (Budapest has the 4th highest figure among the reviewed cities in terms of the population affected by the noise pollution generated by road traffic).
- The concentration of particulate matter (PM_{10}) in the air is occasionally high (the concentration of the 36th most polluted day is the 3rd highest in Budapest among the reviewed cities).
- Local adaptation to climate change means new challenges for the city: due to changes in the indicative flood level preparations are insufficient (over the past few years the Danube flood level was close or exceeded the previously registered highest flood level without ice on a number of occasions).

The environmental programme of Budapest for 2017-2021 – and related thematic plans *(e.g. Budapest Climate Strategy, Budapest Green Infrastructure Concept, Budapest Mobility Plan, Noise Action Plan, Cadastre of brownfield sites)* – contains general and detailed guidelines for the solution of these priority environmental problems and further environmental challenges.

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BUDAPEST

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