Urban Resource Efficiency: The Case of Budapest*

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At the period of urbanization the sustainable uses of natural resources have become more and more important in the most developed countries. Exploring urban material flows could help to better understand complex input-output processes and the material consumption of the population.

The economic changes in Budapest between 1950 and 1990, coupled with a large population increase, brought about greater resource needs and unprecedented waste generation habits. After the political transformation in 1990, radical economic, demographic and social changes occurred, which had altogether a great impact on different resource uses (for example water, energy, land, and food) and resource efficiency.

This paper highlights the economic and environmental transformation of Budapest by emphasizing the following aspects: development and transformation of the economy; material resource consumption and waste generation, as well as related environmental impacts. The main findings and recommendations of the case study can contribute to underpin a more resource-efficient urban policy and design.

KEYWORDS:
Urbanisation.
Environmental statistics.
Sustainable development.

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In 2005, 3.2 billion people lived in cities, four times more than in 1950. With this, the urban population almost reached the half of the Earth's total population. The urban population exceeded the magic number of one billion in 1961. Only one quarter of century needed to grow with another one billion urban inhabitants, and later, only 17 years for a further increase of one billion. This clearly shows the quick pace and irresistibility of the urbanisation process. In 2003 nearly half of the world population lived in cities and this number will reach four billion by 2018 and five billion by 2030. The urbanisation process is well advanced in the developed regions reaching 74 percent of the population in cities. According to different outlooks this rate will increase to 80 percent by 2030 (*OECD* [2008a]). In developing countries the pace of urbanisation is much slower, although it can increase from 43 percent of 2003 to 56 percent by 2030.

In 1950, there were only two megacities, the population of which exceeded 10 million. Half a century later the number of megacities amounted to 20, and it will be 22 in 2015, from which 17 are in developing countries. Today the biggest urban population exists in Tokyo of 35 million inhabitants followed by Mexico City and New York (19–19 million), and Sao Paolo (18 million). In 2005 more than 9 percent of the world population lived in megacities, but this rate will further increase by 2015. The quick urban population explosion of megacities can be illustrated by the fact that since 1950 the population of Delhi has grown eleven-fold, that of Sao Paolo eight-fold and Mexico City seven-fold.

This study is a first attempt to analyse the urban metabolism of Budapest which is a Central-European city and the capital of Hungary. The social, economic and environmental transformation in the last half century can be presented through the use of resources (water, energy, etc.) and the related environmental impacts. This study can not be considered as a comprehensive and quantitative overview of the metabolic processes of Budapest, because it would require further gathering of statistical data and information. At the same time the present phase of the research makes possible to publish preliminary results and to explore certain trends. From the methodological point of view it proved to be easier to examine the input side of urban metabolism, but as we have seen in the cases of other cities, one could face difficulties as regards the output side. Similar problems were found concerning the identification of built-in material stock of the cities (buildings, roads, etc.). On the input side water and energy use, food consumption, while on the output side wastewater, air pollution and municipal solid waste were taken into consideration. At this time the analysis of material stock was limited to building stock and passenger car fleet.

1. The work of the Organisation for Economic Co-operation and Development (OECD) on resource efficiency

Natural resources are fundamental for the economy and prosperity. They provide raw materials, energy, food, water, and land, as well as environmental and social services. The use of materials from natural resources in human activities and the attendant production and consumption processes have many economic, social and environmental consequences that often extend beyond the borders of single countries or regions (*OECD* [2008b]):

> – From an economic perspective, the manner in which natural resources are used and managed affects *a*) the short-term costs and the long-term economic sustainability; *b*) the supply of strategically important materials; and *c*) the productivity of economic activities and industrial sectors.
>
> – From a social point of view, the exploitation and use of natural resources and materials affects employment, human health, and the population's recreational access to particular resources, landscapes and ecosystems. Natural resources also are a basic element of the cultural heritage of many people, notably of indigenous cultures. Furthermore, social equity considerations play an important role in the way revenues and other financial flows associated with resource production and supply are managed, particularly in resource-rich countries.
>
> – From an environmental perspective, the use of natural resources and materials needs to be considered in terms of *a*) the rate of extraction and depletion of renewable and non-renewable resource stocks; *b*) the extent of the harvest and the reproductive capacity and natural productivity of renewable resources; and *c*) the associated environmental burden (for example pollution, waste, habitat disruption), and its effects on environmental quality (for instance air, water, soil, biodiversity, landscape) and on related environmental services.

Making sure that the natural resources and materials are managed well and used efficiently through their life cycle is a key to economic growth, environmental quality and sustainable development. It helps reduce the negative environmental impacts associated with the production, consumption and end-of-life management of natural resources, a concern that has long been on the policy agenda of OECD countries. It also helps indirectly reduce the demand pressures on natural resources in the context of the global economy. This is particularly important in a world, where the prices of many natural resources are rising fast; and where there are often concerns about the long-term security of the supply of natural resources. Supply security is a strategic concern for governments and businesses alike; efficient management of the environmental impacts associated with using these resources will increase their long-term availability (and quality) for everyone.

Over the past two decades, the worldwide use of virtually every significant material has been rising. Growing economic and trade integration among countries has enlarged the size of markets, allowed greater specialisation and mobility in production, increased the role of multinational enterprises, and led to an overall increase in international flows in raw materials and manufactured goods. In consequence, the scale of many policy issues has widened from the local and national to the global. In recent years, prices for energy and other material resources have risen significantly amid growing demands from OECD and other countries, notably from fast-growing economies. Rising prices affect the manner in which natural resources are supplied to and used in the economy. They also influence decisions about technological development and innovation. Hence, natural resource consumption and the economic efficiency of materials use have become important issues, adding to longstanding concerns about natural resource management and the environmental effectiveness of materials use (*OECD* [2008b]).

In the next 50 years, the world population will continue to grow, as will the world economy, placing increasing strains on a variety of material and energy resources and the global environment. This creates unprecedented economic and environmental challenges for policy- and decision-makers. The question arises as to how to sustain economic growth and welfare in the longer term whilst keeping negative environmental impacts in check and preserving natural resources.

1.1. The political importance of resource efficiency

Responding to these issues, the Heads of State and Government of the G8 countries paid specific attention to the resource basis of economies at their summits in 2003, 2004, 2006, 2007, and 2008.

In 2004, the OECD Council adopted a “*Recommendation on material flows and resource productivity*” asking OECD countries to improve information and knowledge on material flows and resource productivity and to develop common methodologies and measurement systems, with emphasis on areas in which comparable and practicable indicators can be defined (*OECD* [2004]). In early 2008, the OECD Council adopted the second “*Recommendation on Resource Productivity*” that urges member states with regard to the analysis of the material flows and their environmental impacts and to policies relating to the improvement of resource productivity (*OECD* [2008c], [2008d]):

> – to improve the scientific knowledge concerning the environmental impacts and costs of resource use,
>
> – to upgrade the extent and quality of data on material flows,
>
> – to further develop and to promote the use of indicators for the assessment of the efficiency of material resource use including indicators to measure resource productivity and decoupling of resource use from economic growth,
>
> – to use information on material flows and their environmental impacts for planning purposes and target settings.

In 2007, an International Panel on Sustainable Resource Management was set up by the United Nations Environment Programme (UNEP) with the support of the European Commission to address resource efficiency issues from a life-cycle perspective, and to provide scientific assessment on the associated environmental impacts. Sustainable resource use is further supported by international efforts to promote good governance in the raw materials sector and to make the management of natural resource rents more transparent.

In the late 1990s, Eurostat in co-operation with other relevant international organisations such as OECD and UN Statistical Division elaborated and published a comprehensive methodological framework for analysing economy-wide material flow accounts (*Eurostat* [2001]). This methodology provides a practical tool for establishing material flow accounts and balances and for deriving a set of physical indicators for a whole economy. The guide also offers help to compilers on the types of accounts to be implemented first, on data sources and methods and on the interpretation of the derived indicators. Material flow analysis (MFA) can be applied to a wide range of economic, administrative or natural entities, studying the flows of materials within the global economy or within the economy of a region or a country (macro level), within an economic and a sectoral activity (meso level), within a city, a river basin or an ecosystem, a firm or a plant (micro level). Micro level MFA provides detailed information for specific decision processes at business (company, firm, plant) or local level (city, municipality, ecosystem, habitat, river basin) or concerning specific substances or individual products.

2. Urban metabolism

The phenomenon of social metabolism and its territorial presence in the cities of OECD and non-OECD countries was analysed by *Pomázi* and *Szabó* [2006] in detail.

The examination of urban metabolism requires inter- and multidisciplinary approach since cities as ecosystems represent a very complex and comprehensive system of social, economic and environmental processes.

The concept of urban metabolism can help in better understanding of the sustainable development of cities by drawing analogies with the metabolic processes of living organisms. One can discover a lot of similarities between functioning and metabolism of biological organisms and those of cities. Cities transform the incoming raw materials, fuels, food and water into the built environment, human biomass, and residuals (*Decker et al.* [2000]). The analysis of urban metabolism practically means the quantitative exploration of inputs and outputs of energy, water, nutrients, raw materials, and wastes.

Urban metabolism can be defined as a complexity of technical, social and economic processes of cities, manifested in growth, energy production and neutralisation of refuse. Until now only a few studies were devoted to the calculation of energy flows in cities, the researchers rather focused on nutrients, raw materials and the hydrological cycle. Urban metabolism is worth studying from different perspectives. Firstly, the exploitation of resources and the generated waste can be well measured by the features of metabolism; these can be also used as sustainability indicators. Secondly, the analysis of urban metabolism makes possible to measure resource efficiency and to explore the cyclical flows of resources. In addition, this provides a good analytical framework for the accounting of urban stocks and throughputs, for the better understanding of critical processes as well (increasing or decreasing ground water resources, heat islands, long term impacts of hazardous construction materials).

Several factors influence urban metabolism. The urban structure including population density and morphology, and transport technology can influence energy and material flow. In the case of cities with large area and low population density per capita, the energy intensity of transport is much higher in comparison with a compact city. Climate also has a great impact on urban metabolism since heating energy demand is much bigger in a winter under continental climate than in a Mediterranean city. The applied technology, the share of vegetation, the energy prices, the age, and quality of building stock also influence the energy use of cities.

The city studies generally show that metabolism is increasing. This is natural in absolute terms, when the population of cities is also growing. At the same time the per capita values are increasing, too.

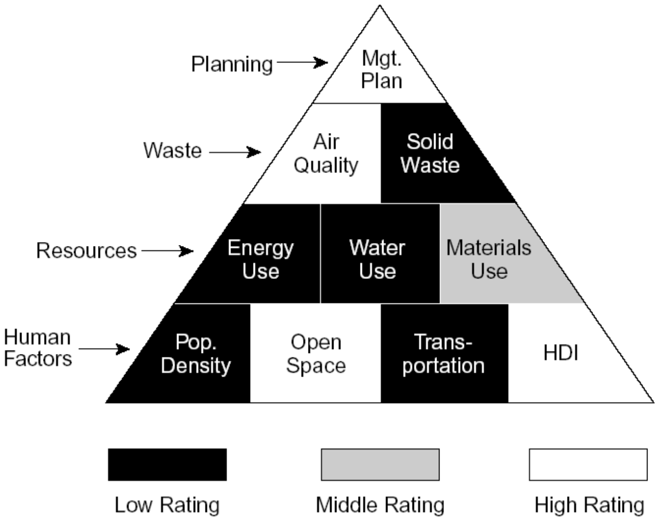
An American engineer, *Abel Wolman* regarded as the father of urban metabolism, described the phenomenon of urban metabolism on the example of a hypothetic one-million city (*Wolman* [1965]).

According to *Wolman* [1965]: "*The metabolism of a city can be defined as all the materials and commodities needed to sustain the city's inhabitants at home, at work* *and at play*". One of Wolman's later followers, *Thomas Graedel* [1999] defined the cities as living organisms: "*Cities can be regarded as organisms, and analyzed as such, in an attempt to improve their current environmental performance and long-term sustainability.*"

Graedel [1999] has elaborated a triangle consisting of ten components to assess urban metabolism, which he called "ecocity metrics" and used it for Vancouver. (See Figure 1.) He set up a system of principles for creating a sustainable city (ecocity) as follows:

- The city must be sustainable over the long term.
- The city must follow a system approach to assess environmental interactions.
- City planning must be flexible enough to be able to follow city growth and changes.
- The open spaces of an ecocity must serve multiple functions.
- The city must become part of regional and global economies.
- The city must be attractive and workable.

Figure 1. The Graedel triangle



Source: *Graedel* [1999].

In the last decades a relatively small number of studies were produced on the changes of urban metabolism. The majority of them focused on cities with big territory and population. One of the initial and comprehensive analyses was prepared on

Brussels by Belgian ecologists *Duvigneaud* and *Denaeyer-De Smet* [1977], which is a classical work of the history of analysing urban metabolism.

The first urban metabolism studies were carried out in the 1970s and 1980s within the framework of UNESCO Man and Biosphere Programme. In 1978, *Newcombe* and his colleagues published a paper on construction materials and the input-output of manufactured products in Hong Kong (*Newcombe et al.* [1978]). Revisiting this study, *Warren-Rhodes* and *Koenig* [2001] pointed out that per capita food-, water-, and material consumption in Hong Kong between 1971 and 1997 increased by 20, 40 and 149 percent, respectively. The increasing trends of per capita resource input and waste production in Sydney were examined by *Newman* [1999]. *Sahely* and his research fellows studied the urban metabolism in Toronto, where for example the amount of household waste decreased between 1987 and 1999 (*Sahely et al.* [2003]). Similar research was performed for Tokyo (*Hanya–Ambe* [1976]), Prague (*Stanners-Bourdeau* [1995]), Vienna (*Daxbeck et al.* [1996], *Obernosterer et al.* [1998], *Hendriks et al.* [2000]), Taipei (*Huang* [1998]), Amsterdam (*Gorree–Kleijn–Van Voet* [2000]), Ann Arbor (*Melaina–Keoleian* [2001]), Greater London (*Chartered Institute of Wastes Management* [2002]), Cape Town (*Gasson* [2002]), Hamburg (*Hammer–Giljum–Hinterberger* [2003]), Tipperary Town, Ireland (*Browne et al.* [2005]), Nantong (*Yu–Huang* [2005]) and Schenzhen (*Yan–Liu–Huang* [2003], *Yan–Zhifeng* [2007]). There are also comprehensive studies containing integrated environmental assessment of 26 and 24 European cities in 2006 and 2007, respectively (*Bono–Castri–Tarzia* [2006], *Berrini–Bono* [2007]). The investigation of urban metabolism can be connected to the application of the ecological footprint methodology of cities. Analytical studies of urban ecological footprint were prepared for Vancouver (*Wackernagel–Rees* [1995]), Santiago de Chile (*Wackernagel* [1998]), Cardiff (*Collins et al.* [2006]), and the cities of the Baltic region (*Folke et al.* [1997]).

The urban audit is also a useful complementary tool for measuring the quality of life in the cities. Following a pilot project for the collection of comparable statistics and indicators for European cities, the first full-scale European Urban Audit took place in 2003, for the then 15 countries of the European Union. In 2004, the project was extended to the 10 new member states plus Bulgaria, Romania and Turkey. Under Eurostat coordination, the work of the Urban Audit involves all national statistical offices. The second full-scale Urban Audit was carried out between 2006 and 2007, and involved 321 European cities (including Budapest) in the 27 member states of the European Union, along with 36 additional cities in Norway, Switzerland and Turkey. Data collection currently takes place every three years, but an annual data collection is being planned for a smaller number of targeted variables (www.urbanaudit.org).

The Urban Audit collected data for over 250 indicators across the following domains: demography, social aspects, economic aspects, civic involvement, training and education, environment, travel and transport, information society, culture and recreation.

3. Budapest

Hungary's capital, Budapest together with its surroundings is a highly developed metropolitan region in Central Europe, where the technical and economic advances have made it possible to support about 2.5 million people (25 percent of the country's total population) on a land area of about 2500 km^2. This population depends on a continual supply of materials, energy and information in everyday function. Economic activities are highly concentrated in Budapest conurbation producing roughly 40 percent of the national Gross Domestic Product.

3.1. Brief history

The land which was settled by the founding Hungarians had been inhabited territory since pre-historical times.

The ensued political and economic stabilization brought about the unification of three historical cities – Buda, Óbuda, and Pest – in 1873. The new city had the name Budapest.

The new era of construction – public and apartment buildings, bridges, and modern local transportation – started, the streets began to be paved - first with rocks and cobblestones then with asphalt. After 1850 construction began on the new water sewer and later gas and electricity systems.

Later, from a governmental standpoint another decisive change took place: on 1st January 1950 the surrounding cities and other settlements were connected to Budapest, and Greater Budapest came into existence with 22 districts (currently 23) in place of the old 10 later 14. By attaching 7 towns and 16 villages to the former Budapest, its area enlarged from 207 km² to 525 km² (154%), the number of its inhabitants increased from 1.05 million to 1.6 million (52%), and the number of its districts augmented from 14 to 22 (57%), thus it became the seventh metropolis of Europe in its time.

In 2007, the main social, economic and environmental indicators of Budapest were as follows:

– Social context:
  Total population: 1.7 million;
  Population density: 3238 capita per km^2.
– Economic context:
  GDP: 40 percent of the country's total GDP;
  Passenger cars: 35 per 100 capita.

– Environmental context:
Green areas: 9.9 m^2 per capita;
Annual municipal waste generation: 630 kg per capita;
Annual CO_2 emissions: 5.7 t per capita.

3.2. Main economic, social and environmental trends

Population of Greater Budapest increased from 1.6 million of the early 1950s to 2.06 million in 1980. From 1980 onwards, the population has been dwindling due to the decreasing birth rate on one hand, and migration to surrounding settlements (suburbanisation) on the other. In 2006, the population dropped to 82.5 percent of its level of 1980. While 19.2 percent of the country's total population lived in the capital in 1980, only 16.8 percent of the population of Hungary counted as residents of Budapest in 2006.

During this time period, the stock of dwellings also changed significantly. According to official statistics, there were 536 thousand dwellings in 1960, their stock has been increasing continuously, although the pace of building panel blocks of flats begun in the 1960s (1.6 percent average increase per year) slowed to an annual 0.5 percent after 1990. Concerning long time series between 1960 and 1990, materials were built into the stock of dwellings of Budapest at such a pace that has never experienced before. This increase is characterised by the fact that the city's population per dwelling was 3.3 capita in 1960, while it was less than 2 capita in 2006. It is also specific that one in five dwellings built in the country during the 1980s was located in Budapest. Panel blocks of flats have been planned for 30–70 year span of life, so the very first ones are approaching the end of their life span, and they are requiring complete renovation or waiting for demolition. In aware of this situation, it is expectable that demolition waste stream will be increasing significantly in the coming decades.

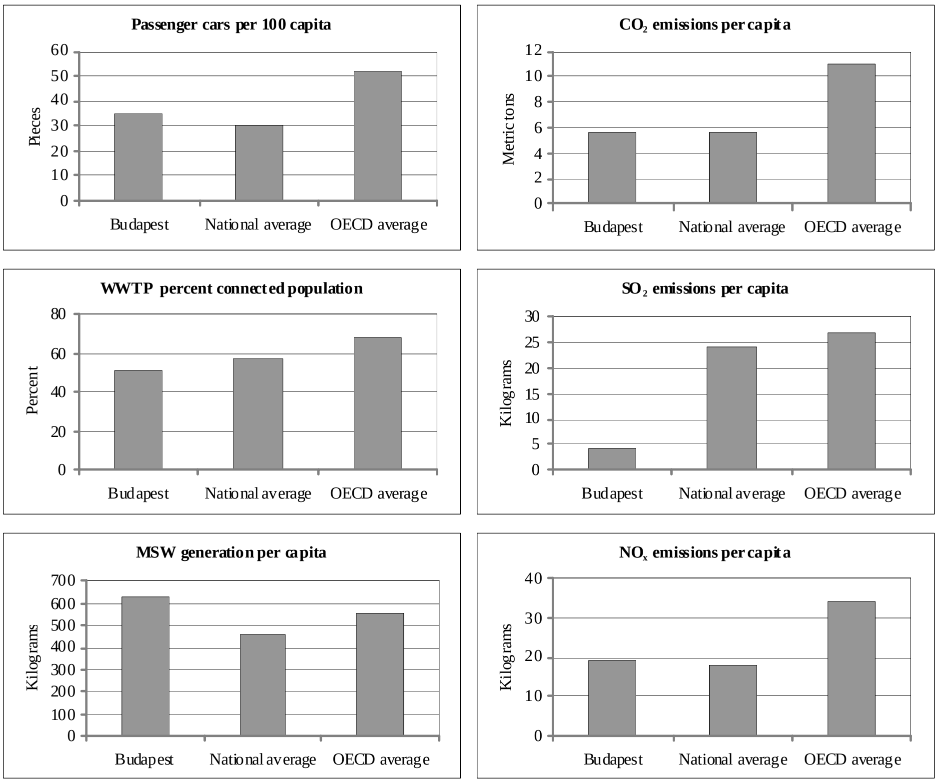
The stock of passenger cars expanded from 39 thousand of 1965 to 596 thousands in 2005 showing a fifteen-fold increase. However, per 100 capita stock of passenger cars still hardly exceeds half of the OECD average (35 versus 52). During these four decades, there was a roughly three-and-a-half-fold enlargement in the stock of buses, while that of lorries increased by almost three-fold.

During the half century covered by the research, inventories of durable goods including refrigerators, washing machines, televisions, etc. enlarged outstandingly and major transformations occurred in their structure. Since elements of the stock sooner or later will emerge on the output side of material flows as waste streams and can cause serious environmental consequences, their investigation is indispensable for mapping the overall picture of material flows. However, a detailed analysis of household statistics is required in order to understand the process in depth. According to the data of 2005, the per capita municipal solid waste generation was about 630 kg compared with the national average of 460 kg and the OECD average of 560 kg.

Data of 2005 show that hardly half of the population of Budapest is connected to waste water treatment plants. At the same time, this share barely approached 35 percent at the national level, while the OECD average was about 70 percent. However, a significant increase is probable in the share of the population connected to waste water treatment plants (WWTP) if a new waste water treatment plant being under construction with high purification capacity is installed.

As far as the emissions of air pollutants are concerned, both Budapest and country data are below – sometimes well below – the OECD average in the case of sulphur dioxide, nitrogen oxides and carbon dioxide. The gap is very significant for sulphur dioxide: while national average is next to the OECD average, per capita emissions of Budapest are one fifth and one sixth of their values, respectively. In the case of nitrogen oxides and carbon dioxide due to transport volume and concentration, the emissions of the capital exceed the national levels, however, they are only about half of the OECD average. (See Figure 2.)

Figure 2. Comparison of selected environment-related indicators, 2005



Note: WWTP: waste water treatment plant; MSW: municipal solid waste.
Source: The authors'own calculation based on Hungarian and OECD statistics.

3.3. Evolution of urban metabolism in historical perspective for the period of 1955–2005

In the longitudinal investigation of the urban metabolism of Budapest the following components were used on the input side:

- total water consumption,
- total (natural) gas consumption,
- total electricity consumption,
- total quantity of heat,
- food consumption.

On the output side of urban metabolism the following components were available in longer time series:

- total waste water,
- total municipal solid waste collected,
- emissions of air pollutants (CO_2, SO_2, NO_x, CO and particulate matter).

Since the units of the previously mentioned elements are differing from one another (m^3, MWh, t), their transformation is inevitable to aggregate the constituents of material flows both on input and output sides into one major flow of materials and energy. The common unit is metric ton, a widely used mass unit in material flow analysis.

In the case of water consumption, 1 m^3 water accounts for 1 ton water, while in gas consumption 1000 m^3 gas equals to 0.74 ton gas. As for electricity, the situation is more complex because until the mid-1980s electricity generation was mainly based on hard coal, but later, energy production was switched over – in a relatively short time period – to the use of natural gas. According to this fact, the following transformation figures were used: between 1955 and 1985: 1 MWh ~ 0.086·0.7 ~ 0.0602 ton oil equivalent (toe), after 1985: 1 MWh ~ 0.086 toe. Similarly, in the case of heat consumption: between 1970 and 1985: 1TJ ~ 23.887·0.7 ~ 16.721 toe, after 1985: 1TJ ~ 23.887 toe.

Researching the total resources consumption of Budapest (without construction materials) between 1965 and 2005, the following main scientific findings can be highlighted:

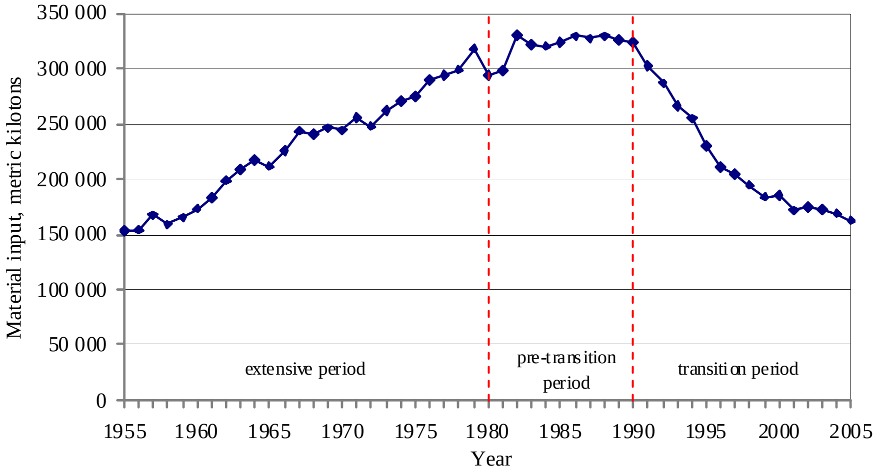
- In 1965, the per capita total resources consumption together with water consumption was 114.5 tons, while it was 0.88 ton without water consumption showing that the used water quantity was about one hundred and thirty fold compared with other resources. In 2005, this indicator pair was 88 and 1.8 tons per capita, respectively, which means about fifty-fold more consumption of water than that of other resources.

– In 1965, total water consumption was 210 million tons, while it reached 327 million tons in 1986 (this latter was the maximum value of the studied time period, and was also an absolute record in the history of Budapest); in 2005, water consumption was 160 million tons accounted for 75 percent of the level of 1965, however, it dropped by more than 50 percent compared with the record.

On the basis of the study on total resource use of Budapest covering half a century, three main periods could be distinguished.

Concerning the input side of resource efficiency, the first period lasted from 1955 to 1980, which can be considered as the extensive socialist development phase of the metropolis. In this era, energy and water use, as well as food consumption increased at a significant pace. The next shorter period between 1980 and 1990 can be regarded as a pre-transition period characterised by temporary stagnation of resource use. The third period begun in 1990 is featured by a robust improvement in resource efficiency.

Figure 3. Evolution of urban metabolism in historical perspective – input side, 1955–2005

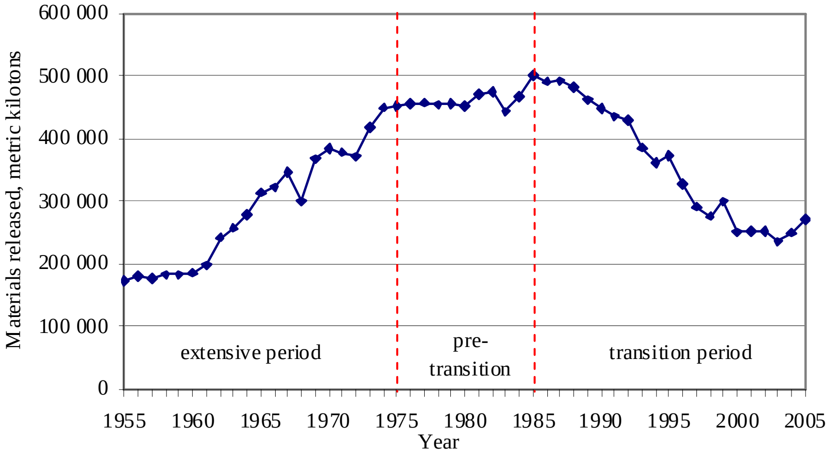


Source: The authors' own calculation.

This development of resource productivity can be explained by the notable decrease of the population, the transformation of the consumption patterns of the city, and a more consequent application of the "user pays" principle. The latter one convincingly shows, for example, that water fees increased by two and a half fold during the last decade, and as a consequence, the consumption habits of households altered rapidly (water consumption decreased by about one fourth). (See Figure 3.)

Considering the output side of resource efficiency, a five-year shift can be recognised, compared with the input side. The output side can be divided into the following periods: the first one (extensive period) lasted from 1955 to 1975; the second one, the era of stagnation or pre-transition period was between 1975 and 1985, while the third period (transition period) is still going on, although not so "spectacularly" as in the case of the input side. (See Figure 4.)

Figure 4. Evolution of urban metabolism in historical perspective – output side, 1955–2005



Source: The authors' own calculation.

The annual quantity of collected municipal solid waste increased by about fivefold (from 120 to 630 kg per capita) between 1955 and 2005. This trend unambiguously shows the specific features of the "throwing away" consumption society of Budapest. The change in the composition of waste between 1990 and 2005 illustrates the previously mentioned alteration of consumption patterns. At the beginning of the 1990s the share of plastics in waste was about 5 percent, however, it has been significantly increasing from 1997 onward, and its share approached 17 percent in 2005. (See Table.) One of the major measuring tools of urban metabolism is the monitoring of waste flows, and the diversion of waste streams from final disposal and incineration, namely the prevention and reduction of waste generation, as well as the reuse and recycle of waste. “3R” policies (reduce, reuse, and recycle) initiated by Japan and confirmed at several G8 summits can be used at the city level as well, and should be regarded as an important part of sustainable city planning (*Namiki* [2008]).

Composition of municipal solid waste in Budapest, 1990–2005
(percent)

Year	Paper	Plastics	Plastics with paper	Textile	Degradable organic matter	Glass	Metal	Hazardous waste	Other inorganic and fine fraction (<16 mm)	Hospital waste
1990	19.6	4.6		6.8	32.3	5.3	6.0	..	25.4	..
1991	17.9	4.6		3.1	38.3	3.4	4.3	..	28.4	
1992	18.5	4.4		4.3	38.9	4.8	4.4	..	24.7	
1993	17.1	5.6		6.5	34.6	5.0	4.8	..	26.4	
1994	18.2	5.7		5.3	33.4	4.7	4.0	..	28.7	
1995	17.0	3.5		4.3	35.1	3.1	4.2	..	32.8	..
1996	19.0	4.5		3.4	32.4	3.0	3.8	1.1	32.8	
1997	19.2	3.5	8.0	5.8	28.4	2.8	2.2	0.8	29.3	
1998	18.3	9.3		6.4	31.4	4.7	3.9	1.0	22.0	3.0
1999	20.2	12.3		5.1	30.7	4.3	3.1	0.6	20.7	3.0
2000	13.7	9.8		3.5	40.7	2.5	1.8	0.2	26.5	1.3
2001	16.0	13.0		2.5	40.4	2.2	1.6	0.3	22.0	2.0
2002	16.3	15.9		3.0	30.7	2.4	1.8	0.4	27.2	2.3
2003	15.6	14.9		3.0	29.7	2.5	1.9	0.5	29.4	2.5
2004	15.2	15.4		2.9	30.6	2.3	1.9	0.6	28.9	2.2
2005	14.6	16.7		3.0	29.4	2.2	1.8	0.5	29.4	2.4

Source: *HCSO* [2006].

3.4. Resource-related targets selected from the Budapest Environmental Programme of 2008–2013

In 2007, the Budapest City Council adopted the Budapest Environmental Programme for the period of 2008–2013 that includes several measures aiming at a more efficient use of natural resources. In the field of energy management, it was targeted that total energy consumption of Budapest should be reduced by ten percent by 2013. To this end, insulation of buildings, as well as individual heat metering of blocks of flats and regulation of heating systems shall be continued. A ten-percent reduction should also be reached in energy consumption of the city-owned public institutions.

The share of using renewable energy sources shall achieve five percent in total energy consumption.

Green areas play a very important role in the "life" of a metropolis since they can for example reduce significantly the risk of emerging of a city heat island. According to the Budapest Environmental Programme, the green area coverage shall be maintained at its 2005 level, and the per capita figure shall exceed the 2005 level (6.2 m^2).

The indicative target to reduce the per capita solid municipal waste generation is 540 and 500 kg by 2013 and 2020, respectively (it was 580 kg in 2006). The share of selective waste collection should be improved by another 5 percent, while that of biologically degradable organic waste should be increased from 4 percent to 25 percent and that of packaging waste from 50 percent to 60 percent by 2013.

The Budapest Environmental Programme, unfortunately, does not set up indicative targets for waste water treatment, although it is one of the "hottest" environmental problems in the capital of Hungary. In Budapest, untreated waste water represents quite a high proportion (only 51 percent of the waste water is treated biologically), and almost half of the waste water is canalised directly into the Danube as a major sink.

4. Conclusions and recommendations

Based upon the analysis of urban efficiency in Budapest, the following conclusions and recommendations are drawn:

– The *OECD* recommendations [2004], [2008d] related to resource productivity and material flows are very useful instruments to measure resource productivity at the micro level including cities.

– Data gaps in time series and methodological changes strongly limit overall calculations of aggregated material flow indicators and without careful consideration this can easily lead to misinterpretation.

– Data availability both in quality and quantity on output side should be improved in comparison with input side data.

– Disaggregated information could provide much more relevant messages for policy-makers than highly aggregated indices at the micro level.

– Better exploration of dissipative resource flows (for example loss of water, heat and hazardous substances) and the net addition to stock and food-related flows can underpin resource efficiency measures.

– The policy relevance of material flows related information should always be taken into consideration.

– The analysis of urban metabolism/efficiency can contribute to sustainable city planning and help to prepare cost effective policies and measures.

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