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URBAN RESOURCE EFFICIENCY: THE CASE OF BUDAPEST

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 total Earth's population. The urban population exceeded the magic one billion number in 1961. Only one quarter of century needed to grow with other one billion urban inhabitants, and later only 17 years for further one billion increase. 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 per cent of the population in cities. According to different outlooks this rate could exceed 80 per cent by 2030 (OECD 2008a). In developing countries the pace of urbanisation is much slower, although it can increase from 43 per cent in 2003 to 56 per cent by 2030.

In 1950, there were only two megacities which population exceeded 10 million. Half century later the number of megacities amounted 20 and in 2015 it will be 22 from which 17 in developing countries. Today the biggest urban population exists in Tokyo with 35 million inhabitants followed by Mexico City and New York (19–19 million) and Sao Paolo (18 million). In 2005 more than 9 per cent of the world population lived in megacities, this rate will further increase by 2015. The quick urban population explosion of megacities can be illustrated by the fact that the population of Delhi increased 11-fold, that of Sao Paolo 8-fold and Mexico City 7-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 related environmental impacts. This study cannot 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 research makes possible to publish preliminary results and to explore certain trends. From the methodological point of view it was proven 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 at the output side. Similar difficulties 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.

The work of 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 short-term costs and long-term economic sustainability; the supply of strategically important materials; and 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 a 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 the rate of extraction and depletion of renewable and non-renewable resource stocks; the extent of harvest and the reproductive capacity and natural productivity of renewable resources; and the associated environmental burden (e.g. pollution, waste, habitat disruption), and its effects on environmental quality (e.g. air, water, soil, biodiversity, landscape) and on related environmental services.

Making sure that natural resources and materials are managed well and used efficiently through their life cycle is 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 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 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, 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. So will the world economy, thus 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.

Political importance of resource efficiency

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

In 2004, the Council of the OECD 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" which recommends to the member countries with regards to analysis of material flows and their environmental impacts and to the policies concerning the improvement of resource productivity (OECD 2008c, 2008d):

– improve scientific knowledge concerning the environmental impacts and costs of resource use;
– upgrade the extent and quality of data on material flows;
– further develop and 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;
– use of information about material flows and their environmental impacts for planning purposes and target settings.

In 2007, an International Panel on Sustainable Resource Management has been set up by the United Nations Environment Programme (UNEP) with the support of the European Commission to address resource efficiency issues from a lifecycle 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.

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 the economy of a region or country (macro level), within an economic and sectoral activity (meso level), within a city, river basin or 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.

Urban metabolism

The phenomenon of social metabolism and its territorial presence including cities was analysed by Pomázi and Szabó in details in the cities of OECD and non-OECD countries (Pomázi–Szabó, 2006). The examination of urban metabolism requires inter- and multi-disciplinary approach, since cities as ecosystems represent a very complex and comprehensive system of social, economic and environmental processes.

The concept of urban metabolism could help in better understanding sustainable development of cities in such a way that it explores analogies with metabolic processes of living organisms. One can discover a lot of similarities between functioning and metabolism of biological organisms and cities. The cities transform incoming raw materials, fuels, food and water into 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.

The urban metabolism can be defined too as a complexity of technical, social and economic processes in cities which is manifested in growth, energy production and neutralisation of refuse. Until now a few studies were devoted to calculation of energy flows in cities, the researchers rather focused on nutrients, raw materials and hydrological cycle. It is worth to study urban metabolism from different perspectives. Firstly, the exploitation of resources and the generated waste can be well measured by 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 cyclical flows of resources. In addition, this provides a good analytical framework for accounting of urban stocks and throughputs, for better understanding of critical processes as well (increasing or decreasing ground water resources, heat island, long term impacts of hazardous construction materials).

Several factors influence urban metabolism. 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 energy intensity of transport is much higher in comparison with a compact city. The climate also has a great impact on urban metabolism, since under the continental climate winter heating energy demand much bigger than in a Mediterranean city. The used technology, the share of vegetation, energy prices, the age and quality of building stock also influence the energy use of cities.

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

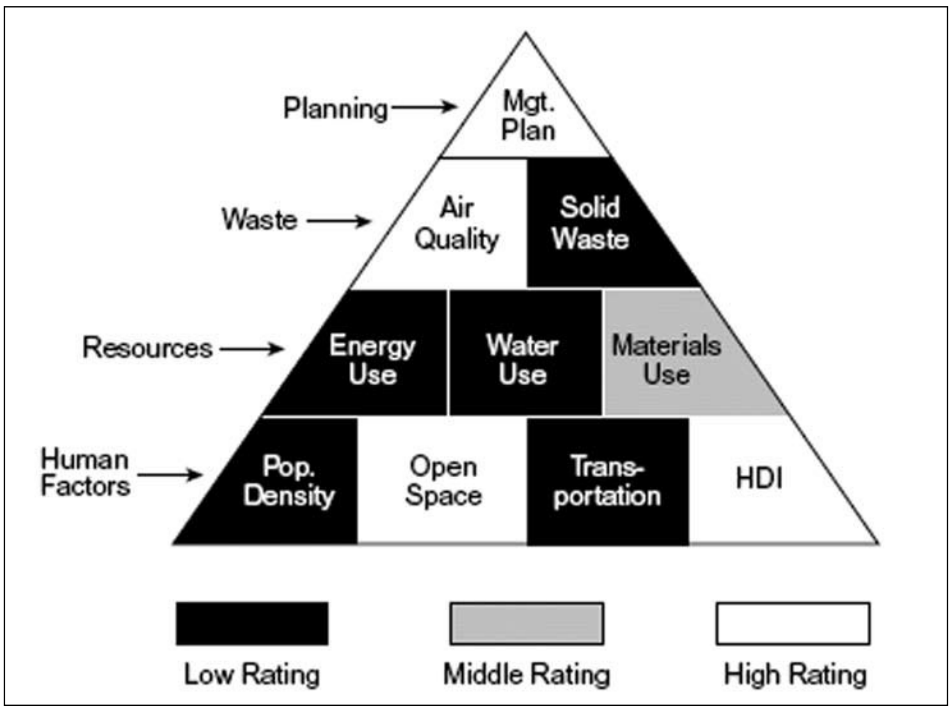
An American engineer, Abel Wolman is regarded as the father of urban metabolism, who described the phenomenon of urban metabolism on the example of a hypothetic, 1 million city (Wolman, 1965).

According to Wolman: „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" (Wolman, 1965). One of Wolman's later followers, Thomas Graedel 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, Th. 1999)

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

– City must be sustainable for a longer term.
– 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.
– Open spaces of ecocity must serve multiple functions.
– City must become part of regional and global economy.
– City must be attractive and workable.

In the last decades a relatively small number of studies were produced on the changes of urban metabolism. The majority of studies focused on cities with big territory and population. One of the first and comprehensive studies was prepared on Brussels by Belgian ecologists Duvigneaud and Denaeyer-De Smet (Duvigneaud–Denaeyer-De Smet, 1977); this study represents a classical one in the history of analysing urban metabolism.



Source: Graedel, Th. 1999

Figure 1.: *The Graedel triangle*

The first urban metabolism studies were carried out in 1970's and 1980's within the framework of UNESCO Man and Biosphere Programme. In 1978, Newcombe and his colleagues published a study on construction materials and input-output of manufactured products in Hongkong (Newcombe et al. 1978). Revisiting this study Warren-Rhodes and Koenig pointed out that per capita food, water and material consumption in Hongkong between 1971 and 1997 increased by 20, 40 and 149 percent, respectively (Warren-Rhodes, 2001). The increasing trends of per capita resource input and waste production in Sydney were examined by Newman (Newman et al. 1996). Sahely and his research fellows studied the urban metabolism in Toronto, where for example the amount of household waste decreased between 1987 and 1999 (Sahel et al. 2003). Similar research was made for Tokyo (Hanya–Ambe, 1976), Vienna (Hendriks et al. 2000), Greater London (Chartered Institute of Wastes Management 2002), Cape Town (Gasson, 2002) and Tipperary Town, Ireland (Browne et al. 2005). Comprehensive studies contain 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).

Box 1.: *Studies on metabolism of cities*

– Tokyo (Hanya, T.–Ambe, Y. 1976)
– Brussels (Duvigneaud, P.–Denaeyer-De Smet, S. 1977)
– Hong Kong (Newcomb, K. et al. 1979, Warren-Rhodes, K.–Koenig, A. 2001)
– Prague (Stanners, D.–Bourdeau, Ph. 1995)
– Vienna (Daxbeck, H. et al 1996, Obernosterer, R. et al. 1998, Hendriks, C. et al 2000)
– Sydney (Newman, P. W. G. 1996)
– Taipei (Huang, S. 1998)
– Cape Town (Gasson, B. 2002)
– Shenzhen (Yan, W. H. et al 2003, Yan, Z. H.–Zhifeng, Y 2007)
– Amsterdam (Gorree, M. et al. 2000)
– Ann Arbor (Melaina, M.–Keoleian, G. 2001)
– London (Chartered Institute of Wastes Management 2002)
– Hamburg (Hammer, M. et al. 2003)
– Toronto (Sahely, H. R. et al. 2003)
– Nantong (Yu, S. T.–Huang, X. J. 2005)

Main economic, social and environmental trends in Budapest

Population of Greater Budapest[1] increased from 1.6 million in early 1950s to 2.06 million in 1980. From 1980 onwards, the population has been dwindling due to, on one hand, decreasing birth rate and, on the other hand, migration to surrounding settlements (suburbanisation). In 2006, population reached 82.5 per cent of its level of 1980. While

[1] On 1 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 km˛ to 525 km˛ (154 per cent), the number of its inhabitants increased from 1.05 million to 1.6 million (52 per cent), and the number of the districts augmented from 14 to 22 (57 per cent), thus becoming the seventh metropolis of Europe in its time.

19.2 per cent of country's total population lived in the capital in 1980, only 16.8 per cent of the population of Hungary counted as residents of Budapest.

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

Box 2.: *Main economic, social and environmental indicators of Budapest, 2006*

Social context:
Total population: 1.69 million
Population density: 3. 219 capita per km^2
Economic context:
GDP: 45 per cent of country's total GDP
Passenger cars: 349,3 per 1000 capita
Environmental context:
Green areas: 9.9 m^2 per cap.
Annual municipal waste generation: 630 kg per capita
Annual CO_2 emissions: 5.7 t per capita

Source: Hungarian Central Statistical Office

The stock of passenger cars expanded from 39 thousand in 1965 to 596 thousands in 2005 showing a thirteen-fold increase. However, per 1000 capita stock of passenger cars still hardly exceeds half of the OECD average (350 vs. 520). In the course of this four decades in the stock of buses was roughly 3.5-fold enlargement, while the stock of lorries increased by almost 3-fold.

Stock of durable goods including refrigerators, washing machines, televisions etc. during the half century covered by the research has outstandingly enlarged and major transformations have occurred in its structure. Since the 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, therefore their investigation is indispensable for mapping overall picture of material flows. However, in order to understand the process deeper a detailed analysis of household statistics is required. According to data of 2005, per capita municipal solid waste generation was about 630 kg, in comparing with 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. In the same time, this share at national level approached 35 per cent, and the OECD average was about 70 per cent. Significant increase is expectable in the share of population connected to waste water treatment plant 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, if national average is next to the OECD average but per capita emissions of Budapest is 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 in the capital exceed the national levels, however, they are only about half of the OECD average (Figure 2).

Evolution of urban metabolism in historical perspective, 1955–2005

In the longitudinal investigation of urban metabolism of Budapest it was possible to use the following components in the input side:
- Total water consumption
- Total (natural) gas consumption
- Total electricity consumption
- Total quantity of heat
- Food consumption

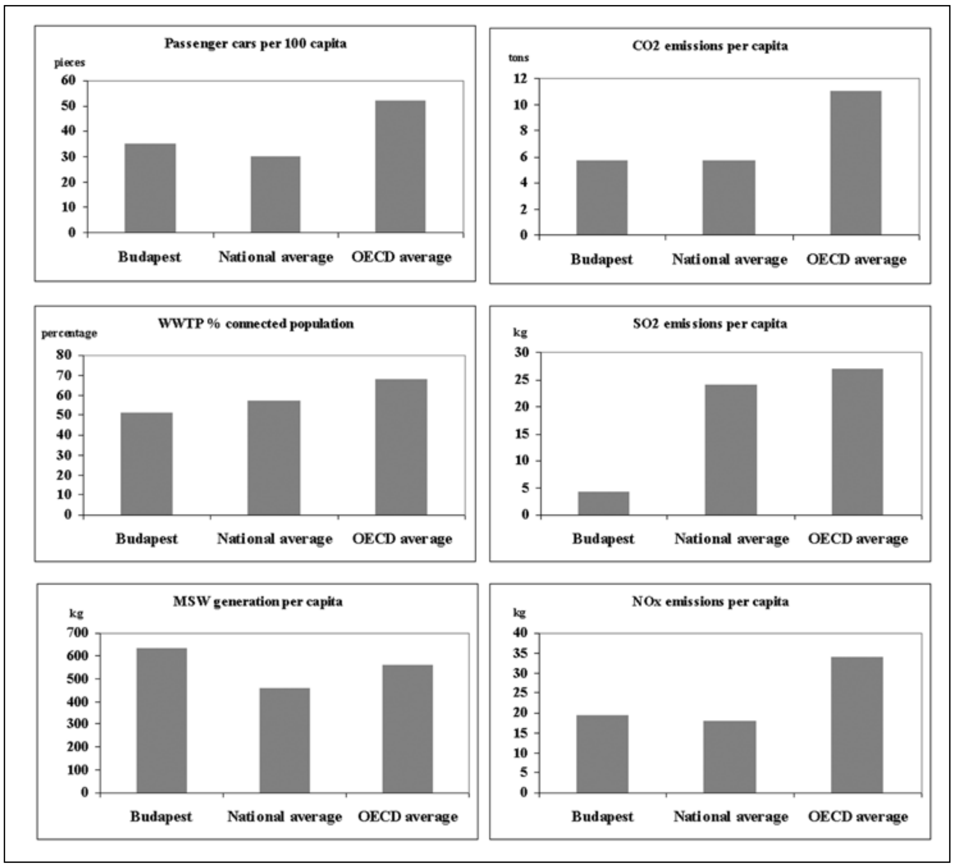
In the output side of urban metabolism, for the following components were available in longer time series:
- Total waste water
- Total municipal solid waste collected

Emissions of air pollutants (CO_2, SO_2, NO_x, CO and particulate matter)
Because of units of the abovementioned elements are differing from each other (m^3, MWh, t) a transformation is inevitable for being able to aggregate constituents of material flows both on input and output sides into one major flow of materials and energy. The common unit is metric ton widely used mass unit in material flow analysis.

In the case of water consumption 1 m^3 water account for 1 ton water, while in gas consumption 1000 m^3 gas equals to 0,74 ton gas. As for electricity the situation is a little bit more complex, because until mid–1980s electricity generation was mainly based on hard coal, later on energy production was switched over–in relatively short time period–to use 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: 1MWh~ 0,086 toe. Similarly, in the case of heat consumption: between 1970 and 1985: 1 TJ ~ 23.887·0,7 ~ 16.721 toe, after 1985: 1 TJ ~ 23.887 toe.

On researching total resources consumption of Budapest (without construction materials) between 1965 and 2005, the following main scientific findings can be highlighted:
- In 1965, per capita total resources consumption together with water consumption was 114.5 tons, without water consumption was 0.88 ton; water quantity used was about 130-fold in comparing with other resources; in 2005, this indicator pair was 88 and 1.8 ton per capita, respectively, which means about 50-fold water consumption than that of other resources' use.

– In 1965, total water consumption was 210 million tons, while in 1986 this figure reached 327 million tons (the maximum value of the time period studied, and was also absolute record in the history of Budapest); in 2005, water consumption was 160 million tons accounted for 25 per cent of the level of 1960, however, comparing to record it shrunk more than 50 per cent.



Source: Own calculation based on Hungarian Central Statistical Office and OECD statistics.

Figure 2.: *Comparison of selcted environment-related indicators, 2005*

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

Concerning input side of resource efficiency, the first period lasted from 1955 to 1980, which can be considered as extensive socialist development phase of the metropolis. In this era both energy and water consumption, as well as food consumption increased by significant pace. The next period, a shorter one, between 1980 and 1990 can be regarded as pre-transition period characterised by temporary stagnation of resources' use. The third period begun in 1990 is featured by robust improvement in resource efficiency. This development in resource productivity can be explained by notable decrease of population, transformation of the consumption patterns of the city, and more consequent use of „user pays" principle. The latter one shows convincingly, for example, that water fee has increased by 2.5-fold during last decade, and as a consequence the households' consumption habits have altered rapidly (water consumption has decreased by about one forth) (Figure 3).

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

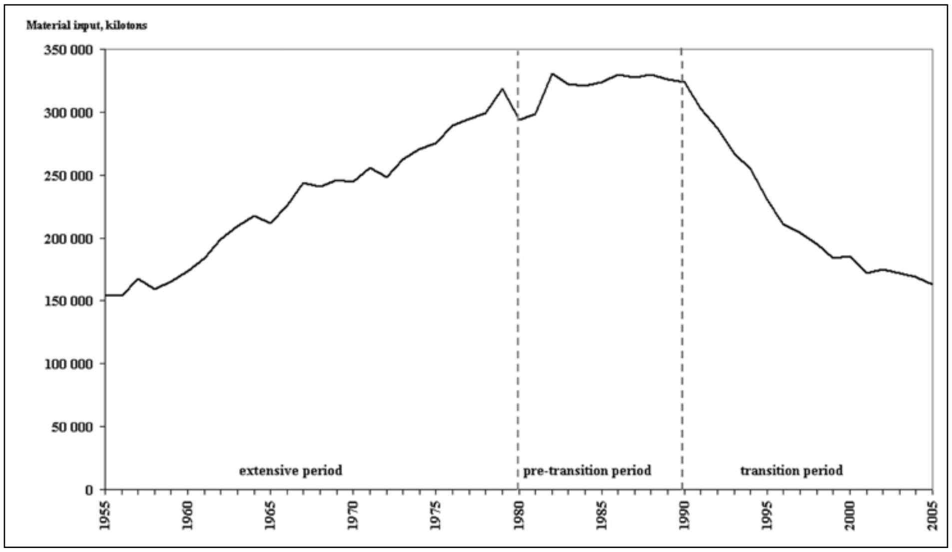
Annual quantity of collected municipal solid waste increased by 5-fold (from 120 to 630 kg per capita) between 1955 and 2005. This trend unambiguously shows specific features of „throwing away" consumption society in Budapest. The change in composition of waste between 1990 and 2005 illustrates the previously mentioned change in consumption patterns. The share of plastics in waste in the beginning of 1990s was about 5 per cent, however, from 1997 onward, it has significantly been increasing, and its share approached 17 per cent in 2005 (Table 1).

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, i. e. prevention and reduction of waste generation, as well as reuse and recycle of waste. „3R" policies (reduce, reuse, and recycle) initiated by Japan and confirmed on several G8 summits can be used at city level as well and should be regarded as important part of sustainable city planning (*Namiki, M.* 2008).

Selected resource-related targets from Budapest Environmental Programme for the period of 2008–2013

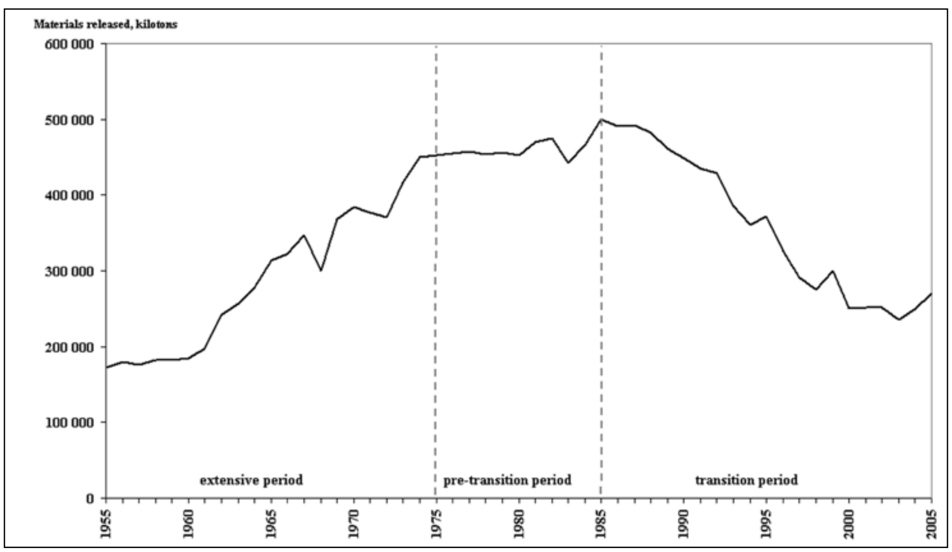
In 2007, Budapest City Council adopted Budapest Environmental Programme for 2008–2013, in which a few measurements indicating more efficient use of naturaresources have appeared. In the field of energy management, it is targeted that total energy consumption of Budapest should be reduced by 10 per cent by 2013. To this end, insulation of buildings as well as individual heat metering of block of flats and regulation of heating systems should be continued. Ten per cent reduction should also be reached in energy consumption of city-owned public institutions. The share of using renewable energy sources shall achieve 5 per cent in total energy consumption.

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



Source: Own calculation.

Figure 3.: *Evolution of urban metabolism in historical perspectives I., 1955–2005 (Resource efficiency in input side)*



Source: Own calculation.

Figure 3.: *Evolution of urban metabolism in historical perspectives I., 1955–2005 (Resource efficiency in input side)*

The indicative target for reducing 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 per cent, while the share of biologically degradable organic waste should be increased from 4 per cent to 25 per cent, and in the case of packaging waste from 50 per cent to 60 per cent, by 2013.

Table 1.
Composition of municipal solid waste in Budapest, 1990–2005 (%)

Year	Paper	Plastics	Plastics with paper	Textile	Degradable organic matter	Glass	Metal	Hazard-ous waste	Other inor-ganic 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: Environmental Statistical Yearbook of Hungary 2005 (2006)

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 a quite high proportion (only 51 per cent of waste water is treated biologically), yet almost half of waste water is canalised directly into the Danube as a major sink.

Conclusions and recommendations

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

– The OECD recommendations[2] related to resource productivity and material flows are very useful instruments to measure resource productivity at micro level including cities.

[2] OECD Council Recommendation on Material Flows and Resource Productivity C(2004)79, OECD Council Recommendation on Resource Productivity C(2008)40

- 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 policymakers than highly aggregated indices at micro level.
- Better exploration of dissipative resource flows (e.g. loss of water, heat and hazardous substances) can underpin resource efficiency measures.
- Policy relevance of material flows related information should always be taken into consideration.
- Analysis of urban metabolism/efficiency can contribute to sustainable city planning and help to prepare cost effective policies and measures.

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