ON COMMUTING RELATED ENERGY CONSUMPTION AND ITS ASSESSMENT

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Summary

The energy consumption of buildings consists of two components: the direct consumption (e. g. heating and operation of home appliances) and the indirect consumption related to the location of the building (e. g. energy consumption of the induced transport). While energy efficiency of the building operation gained sustained research effort resulting in large improvements of energy efficiency, the location-related energy efficiency gained much less attention, as it seemed rather arbitrary and random. This paper focuses on the topic of commuting related energy consumption as it becomes a crucial part of the energy consumption of the recent state-of-the-art passive houses, often reaching multiples of the heating energy consumption. The analysis of transport-related energy consumption in the Czech Republic reveals substantial potential for energy conservation during the development process as the variability between individual localities is large and new development is often located rather inefficiently from this point of view.

Keywords: energy, commuting, settlement, assessment

1 Introduction

The continuing depletion of easily-extractable natural resources, changing geopolitical situation including changing patterns of consumption and increasing geopolitical instability in countries with a substantial share of energy resources, combined with environmental impacts of energy resources extraction and consumption (including global climate change), resulted in increasing interest in energy efficiency and security.

The energy consumption related to buildings and transportation accounts for a substantial part of the overall energy consumption. This resulted in a sustained effort in increasing energy efficiency of buildings – a process crowned with near-zero-consumption buildings becoming the state-of-the-art and a slowly turning into legal standards. On the other hand the energy related to the location of the buildings is still neglected and most new buildings and developments have worse-than-average performance. This is caused by both political reasons and missing methods for the evaluation of energy efficiency of settlement arrangement and spatial patterns of development.

This paper focuses on the latter reason and explores the methods for evaluation of the energy consumption related to the location of the buildings.

2 Literature review

The first attempts to estimate the relation between spatial form of development and energy consumption appeared after the 1970s oil crises. The early research focused on the relationship between the average density of the built-up area and the per capita consumption of transportation energy at the level of large cities [1]. The results suggest the higher is the density of residential areas the lower is the consumption of energy for transportation. Similar conclusions are valid for Brazilian cities as well [2].

The later research has focused on the finer scale of neighbourhoods, e. g. the large research in the Copenhagen area [3]. The energy consumption ranged between 11.5 and 20.1 GJ/year per capita in different parts of the city [ibid.]. The results of the research clearly demonstrate substantial difference between various localities.

Another branch of research has focused on energy vulnerability and the ability to adapt to possible fuel supply disruptions. Dodson and Sipe [4] use the index combining the car dependency related threats and the vulnerability caused by mortgages. The results indicate high vulnerability of the outer suburbs of Australian cities compared to the inner city locations.

Minimum commute is another approach focusing on possibilities of adaptation and on the amount of commuting defined by the urban form itself. Minimum commute is often defined as by an arrangement of commuting when everybody commutes to such a workplace that the total distance of commuting is minimal. This approach was used in the analysis of Flanders [5] and other places. Similar method is used by Rendall et al. [6] for non-commuting private trips. The method is based on the idea of using the mode with minimum energy consumption as long as it is feasible (e. g. until the maximum trip distance for the respective mode is reached).

3 Material and methods

The assessment method is based on two principles. It combines the estimation of average energy necessary for commuting with the minimum energy needed for reaching the non--work targets. The former is based on the Czech Statistical Office census data on commuting between municipalities and the kilometric distance between municipalities while the latter is based on the minimum energy transport activity access model [6].

The evaluation of commuting was calculated using formula (1).

$$E_i = 2.\left(n_p - n_d\right) \sum_j \sum_m n_{ijm.}.\, d_{ijm} e_m \quad (1)$$

The parameter e_m is energy intensity of mode m, d_{ijm} distance between municipalities i and j using mode m, n_{ijm} the number of commuters between municipalities i and j using mode m adjusted according to the total number of commuters, n_p is the number of working days per year and n_d is the number of the days of vacations per year. The energy intensity is based on kilometric distance with per kilometre intensities based on [7].

The analysis of non-commuting trips considered these targets: LAU3-level centre, post office, kindergarten, primary school, secondary school and hypermarket. The number of trips to schools is based on the number of school students per capita and the number of school days per year with 7, 16 and 10 trips per capita and year for kindergartens, primary and secondary schools. We considered one trip to city centre every other week and one trip per month to a post office and a hypermarket.

The estimation of minimal energy consumption considered maximum level of acceptable adaptation. The energy consumption was set to zero if the distance of the target was within the reach of pedestrians (600 meters for kindergartens, 1000 meters for primary schools, 2500 meters otherwise). In other cases we considered (in this order): bicycling for targets in the maximum distance of 5000 meters, public transit for targets with time accessibility up to 10 minutes for kindergartens, 20 minutes for primary schools and 30 minutes and the cars otherwise.

The energy calculation is based on [7] again. One quarter of public transit consumption was considered for bicycles (public transit in the winter, bicycle otherwise). The calculation of public transit is performed using the multimodal network analysis.

We used the ZABAGED data for creating both road and railway networks. The destinations data are based on CENIA data for schools and post offices and on own research for centres and hypermarkets.

4 Results

The results are shown in Fig. 1. See the substantial share of commuting-related energy use. Most suburban localities need much more energy for transportation than for heating a passive house with 3 inhabitants and 100 square metres of floorspace (1800 MJ/person.year), often exceeding multiples of this value.

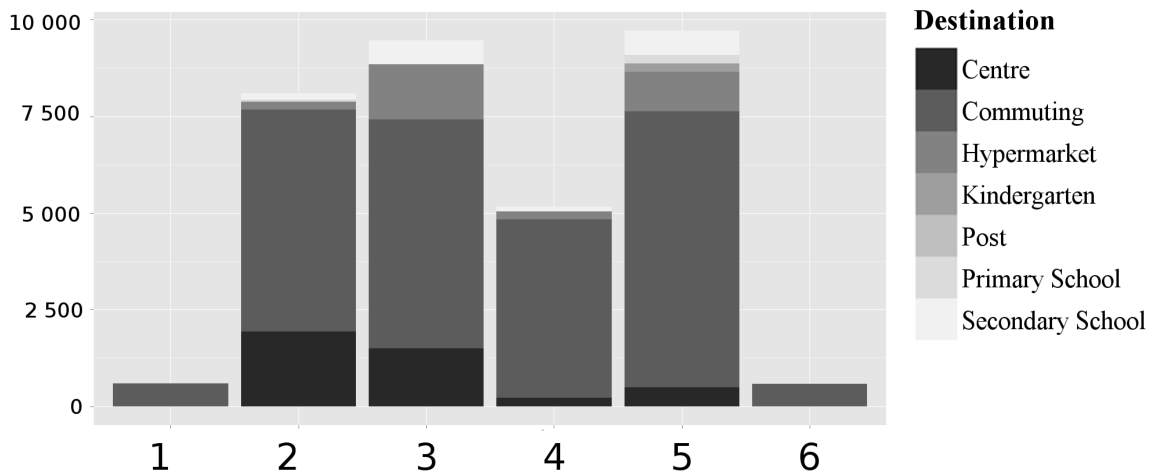

Fig. 1 *The energy [MJ per capita and year] needed for transportation in localities Praha–Háje (1), Libeň (Libeř)(2), Mníšek pod Brdy (3), Řevnice (4), Trnová (5) and Praha–Vinohrady (6)*

5 Conclusions

The analysis confirms the growing relative importance of locality related energy consumption of buildings, especially energy consumption needed for regular trips, including commuting. The substantial differences between inner city localities and suburban localities (especially localities without access to railway and basic amenities) question omitting the evaluation of building location in the evaluations of energy efficiency of buildings.

While the energy efficiency of buildings as such is increasing dramatically, the energy efficiency related to their location follows the opposite trend as most recent developments take place in suburban zones with long distances to both workplaces and amenities and without energy-efficient public transit and therefore with large energy consumption related to transport.

The analysis itself needs further improvements. The numbers of trips and their target destinations should be address with more realistic research. This should include the exploration of alternative targets, e. g. shopping options and more precise differentiation between centres. This might affect the results, especially in suburban towns like Mníšek pod Brdy with its centre being rather attractive but still on the sub-LAU3 level as well as its shopping options being comparable to hypermarket offers if summarized while lacking the status of hypermarket. Intra-municipality commuting should be incorporated as well.

Acknowledgement

This work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS10/303/OHK1/3T/15.

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