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ABSTRACT

Energy consumption by private households and its continuous increase is one of the main target areas for climate policy and energy efficiency strategies. This paper attempts to provide some empirical evidence on the main drivers of private households' energy demand, Analysing data on energy expenditure from National Accounts and the Austrian Consumer Survey. Results show the relevance of various household characteristics (region, size, income, etc.) that can be interpreted as lifestyles for energy demand.

Key words: energy demand, household consumption

INTRODUCTION

Private households' energy use is one relevant factor determining the development of final energy demand in Austria: between 1990 and 2005 the share of private households in final energy demand on average amounted to nearly 30 percent. Although the share has been declining slightly in recent years, the absolute amount of energy used has increased since 1990[1]. The major part of the energy is used for heating and cooling[2].

Measured in terms of greenhouse gas emissions the share of private households has decreased from 32 percent in 1990 to 24 percent in 2007. However, total emissions increased in line with final energy used and are mainly determined by the demand for heating. Regarding transport, half of CO_2 emissions are caused by passenger road transport. Emissions in this segment have increased by 45 percent since 1990 (from 8,7 to 12,7 million tons in 2007). In the same period the number of kilometres travelled by passenger cars increased by 83 percent. Thus, the CO_2 intensity of passenger road transport, i.e. kg CO_2 per kilometer, decreased by 20 percent. This shows, that the rise in efficiency in passenger road transport is accompanied by a pronounced "rebound effect". The improvement in energy efficiency due to technical progress is partly offset by the subsequent growth in demand (kilometers driven)[3].

A range of factors determines households' expenditures for energy in their structure and development over time (*Köppl et al.*, 1995, *Røpke*, 2001, *Kletzan et al.*, 2002, *Kratena – Wüger*, 2004). Other aspects than general socio-economic factors like household income are summarised in Table 1:

[1] There are annual fluctuations in energy use for heating due to climatic conditions. On average final energy demand in the years 1991 to 2007 was higher by 14 percent than in 1990.

[2] Source: Useful Energy Analysis, Statistics Austria, http://www.statistik.at/web_en/statistics/energy_environment/energy/useful_energy_analysis/index.html.

[3] For analyses of the rebound effect see for example Kratena – Meyer (2008), *Greening - Green - Difiglio*, 2000, *Binswanger*, 2001, *Khazzoom*, 1980, *Brännlund - Ghalwash - Nordström*, 2007, *Frondel - Peters - Vance*, 2007.

Table 1: Factors determining households' energy expenditures

Heating	**Electricity**	**Transport**
Type of dwelling	Endowment with electricity consuming appliances	Endowment with cars
- house	- Cooking	Car size
- appartment	- Washing	Car age
Size of dwelling	- Lighting	Mobility needs
Year of construction	- Entertainment	Recreational behaviour
Thermal quality	- Communication	Conspicuous consumption
Number of household members	- Computing	Social habits
User behaviour	Substitution of appliances	.....
.....	Household size	
	User behaviour	
	Conspicuous consumption	
	.....	

Source: Köppl – Wüger, 2007.

Household energy demand for heating, hot water and lighting is essentially dependent on whether the dwelling is a single family house or an apartment. Single family houses on average are larger in living space and are characterised by a higher specific energy demand (kWh per m^2 p.a.). With the increasing diffusion of energy efficient housing technologies (e.g. passive houses) this space related difference plays a lesser role in new construction. But aggregate household energy demand for heating is mainly determined by the existing stock of buildings. In Austria especially buildings from the period 1945 to 1980 that represent a large share of the total stock are characterised by a high specific energy demand[4]. Thus, the construction year is also of importance for energy demand for housing. In addition to the features mentioned so far the size of the dwelling, the number of household members as well as the user behaviour affect energy demand. User behaviour in this respect concerns for example the desired room temperature in day and night time, the use of energy efficient light bulbs, etc.

Electricity demand is mainly determined by the households' endowment with electrical appliances. While household appliances for cooking and washing have been standard equipment for a fairly long time, the growth in appliances for entertainment, communication, computing or cooling has only taken place in the recent past and increasingly affects energy use.

Expenditures for transport have been largely driven by the increase in individual car traffic and the trend towards more powerful vehicles. The preference for car transport is in turn affected by developments in settlement structures (e.g. urban sprawl), rising incomes or changes in recreational behaviour. Another aspect that fosters the trend towards bigger and more powerful vehicles is the role of cars as status symbols.

The alteration in consumption patterns over time leads to changes in energy demand, with different effects caused by household appliances, cars, dwellings.

[4] The average specific energy demand for heating for single family houses of this period amounts to nearly 300 kWh/m2/year. In comparison, the respective value for house built after 1980 is 138 kWh/m2/year. Specific energy demand in multi-storey residential buildings is approximately only half as high.

This paper first presents data on the development of household endowments with various categories of appliances and their energy demand. Then, an analysis of the extent to which energy expenditures for housing and transport are determined by differences in household characteristics is presented. Stylised facts are used to analyse energy expenditure taking into account various household characteristics as well as differences in total consumption and income. These factors were interpreted as differences in lifestyles.
The database for the analysis are the results from the Austrian Consumer Survey 2004/2005 as well as consumption data from the National Accounts and additional energy related information (e.g. energy balances). The data from the National Accounts are used to illustrate the development and structure of consumption expenditure for housing and transport over time. In addition, quantity and price effects for various expenditure categories (e.g. energy sources, transport modes) are calculated.
The consumer survey in turn offers the possibility to analyse energy and transport expenditure at one point in time for households with different characteristics like income, size, age, region, etc., i.e. to identify the respective preferences depending on the socio-economic situation. Thus, on the one hand various kinds of consumption behaviour or lifestyles - determined by the household's endowment (e.g. car ownership) and consumption structure – can be identified. On the other hand it can be assessed what households with different characteristics would consume if differences in the level of income were eliminated. This can be regarded as a first step for clarifying the interdependencies between lifestyles, user behaviour and energy use.

HOUSEHOLD ENDOWMENT WITH ELECTRICAL APPLIANCES, CAR USE AND DWELLING SIZE

Table 2 compares the development in household endowments with various appliances [5]) with the corresponding changes in annual »hypothetical« electricity consumption: this is calculated by the specific electricity consumption multiplied by the number of appliances per category [6]). The annual specific consumption is defined as the amount of energy consumed by a category of appliances on average.
The results show that the number of refrigerators increased by 1,1 percent per year on average between 1980 and 2004, which was driven by the growth in the number of households (1980/2004: +26 percent) and not by higher household endowments. Despite the higher number of refrigerators in use the total energy used by this category of appliances has been declining since the middle of the 1980-s due to significant improvements in energy efficiency (+2,6 percent p.a.).
The increase in the number of freezers, however, is due to changes in consumption patterns. In 1980 on average every second household was equipped with a freezer, in 2004 about 80 percent of households. The specific energy consumption also declined but at a lesser rate than that of refrigerators (- 1,5 percent p.a.). The trend in total electricity consumption of this category (1980/2004 +1,4 percent p.a.) is determined by the change in the quantity of appliances used, i.e. the improvement in energy efficiency is overcompensated by the increase in household endowment.
The rapid permeation of certain technologies can be illustrated by the growth in dishwashers: 1980 only 10 percent of households possessed a dishwasher, the share increased to one third by

[5]) For the analysis of household endowment with electrical appliances data from the Austrian Energy Agency are used. However, comprehensive conclusions are restricted as no information on entertainment and ICT electronics are available that represent are strongly growing category.

[6]) The calculated (hypothetical) electricity demand can be used as a proxy for the total annual energy demand realted to the specific category of appliances.

1995 and further to two thirds by 2004. The specific electricity consumption of this appliance category has decreased by 1,9 percent per year since 1980. However, as in the case of freezers, efficiency gains are offset by the growing number of households and appliances.
Washing machines – like refrigerators – have been standard household equipment for some time. Already in 1980 72 percent of households had a washing machine. In 2004 the share was 94 percent. In this category total annual electricity consumption grew by 1,4 percent on average, compared to an improvement in efficiency of 0,7 percent p.a.. In contrast to this the intensified endowment with tumble driers is a fairly new development. 2004 one quarter of households in Austria were equipped with a drier (+ 12 percent p.a. since 1980) and this category shows the largest increase in total electricity consumption (+ 11 percent p.a.). Although efficiency improved by 1,1 percent per year the specific electricity consumption remains very high [7]).
Regarding entertainment electronics only data for television sets are available. Since 1990 the market penetration rate has been higher than 1 – on average every Austrian household possessed 1,25 TV sets in 2004. In the period 1980 to 2004 the specific electricity consumption decreased by 3,2 percent annually, total electricity consumption of this appliance category by 1,1 percent[8]).
For the aggregate of all appliance categories described above total electricity consumption has grown by 1,2 percent per year. Expressed differently, electricity consumption per household for the six categories grew by 0,2 percent per year. Thus, the development of household electricity use is mainly driven by the increase in the number of households. The rapid technological change and the wide diffusion of other types of entertainment electronics and ICT equipment will constitute an additional driver for electricity consumption in the future.

Table 2: Development of household equipment and appliances

	Change in endowment		Change in specific energy use		Change in hypothetical total energy	
	Quantity in 2004	Ø annual change rate 1980 - 2004	Consumption 2004	Ø annual change rate 1980 - 2004	Consumption 2004	Ø annual change rate 1980 - 2004
	in 1.000	in %	kWh/a	in %	GWh/a	in %
Refrigerator	3.374	+1,1	225	-2,6	759	-1,5
Freezer	2.826	+2,9	534	-1,5	1.509	+1,4
TV	4.293	+2,2	71	-3,2	305	-1,1
Washing machine	3.217	+2,1	230	-0,7	739	+1,4
Dishwasher	2.160	+8,5	360	-1,9	778	+6,4
Laundry dryer	884	+12,0	411	-1,1	363	+10,7

Source: Austrian Energy Agency, »Enerdata«, WIFO-calculations.

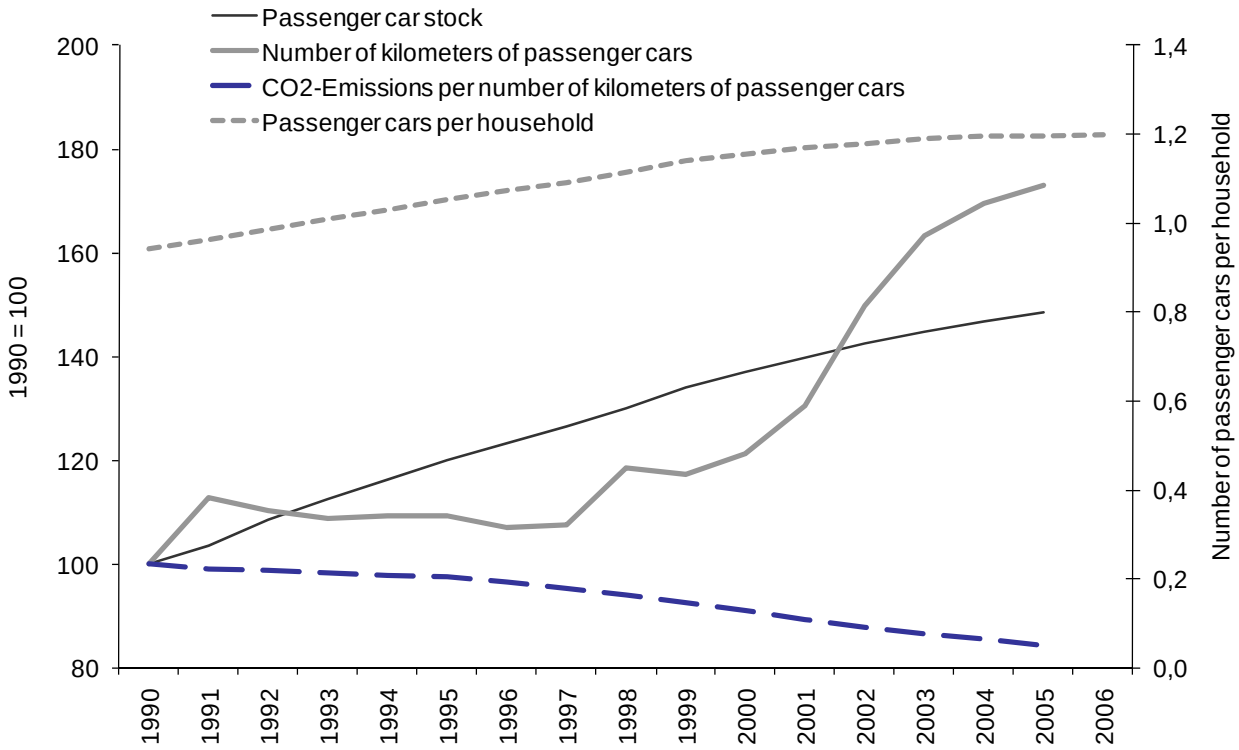
The trend in individual car traffic and the stock of vehicles are further key aspects of household energy consumption. Besides the number of cars the specific fuel efficiency and the intensity of use (kilometers driven per year) are determining total transport related energy consumption and emissions. The stock of cars in Austria has tripled since 1975 (from 1,5 million to 4,2 million in 2006). The rate of car ownership per household has doubled from 0,6 to 1,2 cars. Data on mileage and emissions are available for the period 1990 to 2005 (Figure 1). It shows that the

[7] 411 kWh per year. Only freezers have a hogher specific electricity consumption (534 kWh p.a.).

[8]) It can be assumed that the rapid diffusion of new technologies (e.g. flatscreen TVs) might reverse this trend.

structure of the car fleet has changed significantly, reflecting technological developments as well as alterations in consumer preferences. The share of cars with a cylinder capacity between 1.000 cm^3 and 1.500 cm^3 decreased from 50 percent in 1975 to 25 percent in 2005. In contrast the share of cars with a cylinder capacity between 1.500 and 2.000 cm^3 doubled from 30 percent to 60 percent during this period. Cars with more than 2.000 cm^3 cylinder capacity had the largest annual growth rate (+6,1 percent p.a.), amounting to 14,5 percent of the total car fleet in 2005.

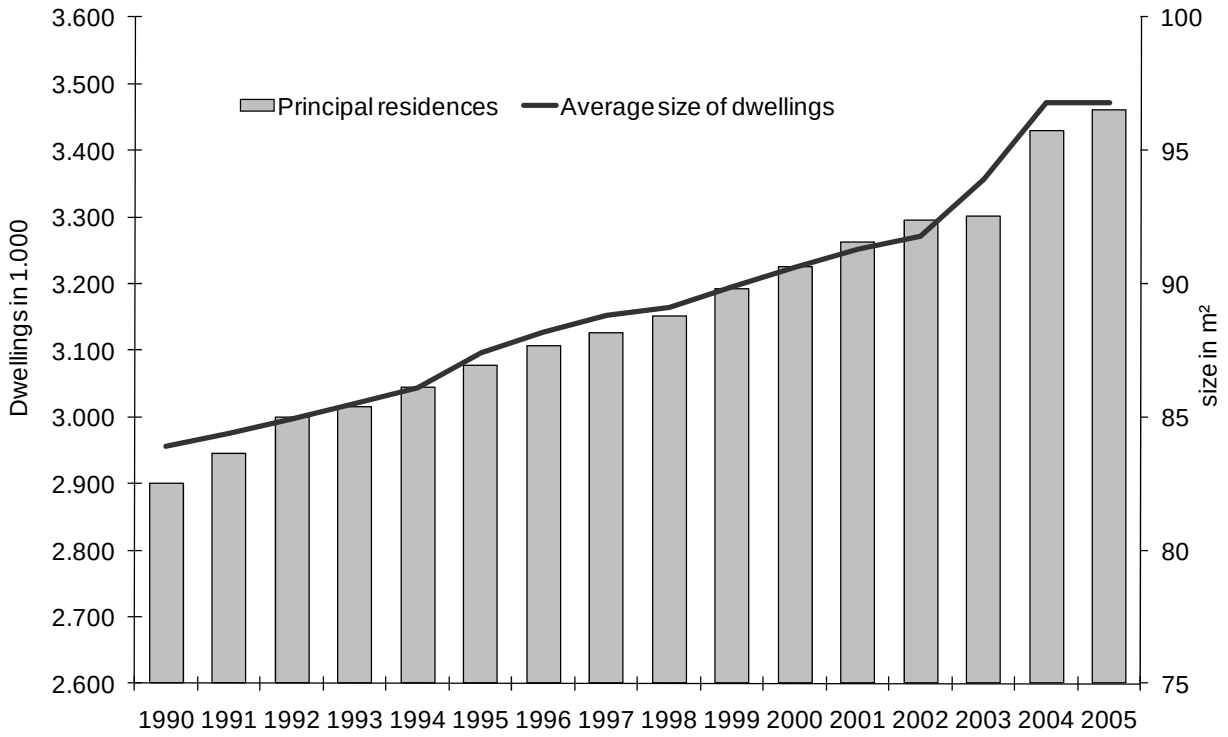
Figure 1: Development of car ownership and mileage



Source: Statistic Austria, Umweltbundesamt, WIFO-calculations.

Regarding housing not only the number of households is relevant for energy use but also their structure (e.g. living space, construction year). Between 1990 and 2005 the number of households (principal residences) increased from 3 million to 3,5 million (Figure 2). In addition the average living space per household increased by more than 10 m^2 (from 84 m^2 to 97 m^2). In total this represents a growth of 38% from 1990 to 2005.
This development lead to a rise in energy consumption from 67.345 GWh in 1990 to 79.317 GWh in 2005 according to data from the Austrian energy balances. Energy consumption per m^2 however declined slightly (-14 percent), pointing to an improvement in the thermal quality of residential buildings. Subtracting a share of 10 percent that can be attributed to lighting and computing (*Maye*r, 2006), the average energy use for heating is still higher than 200 kWh per m^2 and thus clearly above the values of energy efficient buildings (e.g. less than 45 kWh per m^2 and year for low energy buildings).

Figure 2: Number of Principal residences and average size of dwellings



Source: Statistic Austria, WIFO-database.

ENERGY COSNUMPTION ACCORDING TO NATIONAL ACCOUNTS: QUANTITY AND PRICE EFFECTS

National accounts provide data on the development and structure of private households' expenditures for energy and transport for the period 1995 to 2005. Changes in nominal expenditure shares for heating/lighting and transport in total consumption expenditures for two periods were divided into quantity and price effects according to equation (1). This was calculated for individual energy sources and transport categories in relation to total energy consumption for housing and transport.

$$(1)\quad \frac{A_t}{A_0} = \frac{AR_t \cdot P_t}{AR_0 \cdot P_0} = \frac{e^{(\lambda_E+\mu_E)\,t}}{e^{(\lambda_C+\mu_C)\,t}} = \underbrace{e^{(\lambda_E-\lambda_C)\,t}}_{\text{quantity-effect}} \cdot \underbrace{e^{(\mu_E-\mu_C)\,t}}_{\text{price-effect}},$$

$A_t = \frac{E_t}{C_t}$ . . . Share of energy expenditures in total private consumption in period t, nominal,

$A_0 = \frac{E_0}{C_0}$ . . . Share of energy expenditures in total private consumption in period 0, nominal,

$AR_t = \frac{ER_t}{CR_t}$ . . . Share of energy expenditures in total private consumption in period t, real,

$AR_0 = \frac{ER_0}{CR_0}$ . . . Share of energy expenditures in total private consumption in period 0, real,

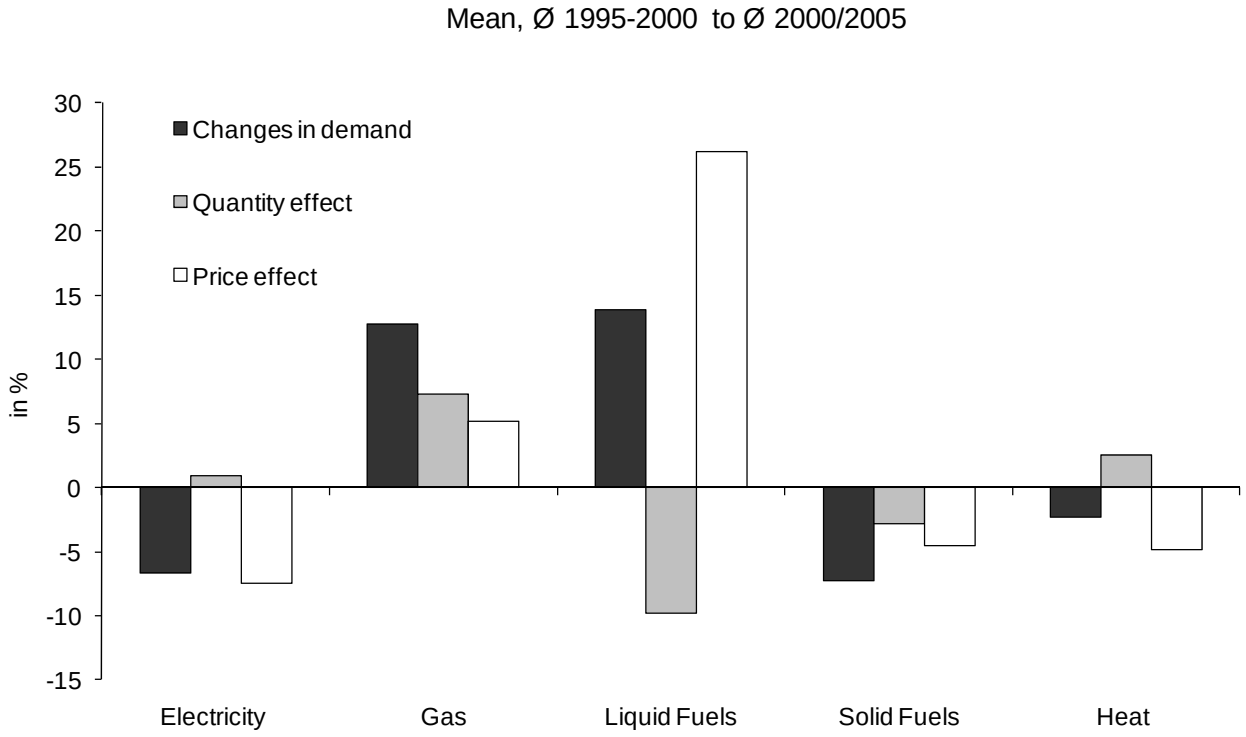
E . . . Energy expenditures, nominal,
C . . . private consumption, nominal,

ER . . . Energy expenditures , real,
CR . . . relevant total consumption expenditures, real,
PE . . . Energy price (calculated from nominal and real expenditures),
PC . . . consumption price (calculated from nominal and real expenditures),
P_t . . . relative energy price in period t $\left(P_t = \frac{PE_t}{PC_t}\right)$,
P_0 . . . relative energy price in period 0 $\left(P_0 = \frac{PE_0}{PC_0}\right)$,
λ . . . real rate of change of consumption and energy expenditures,
μ . . . rate of change in consumption and energy prices.

Weather conditions lead to fluctuations in energy expenditures for heating between two years. In order to avoid the influence of specific weather conditions in one year on the decomposition of changes in shares the means for the periods 1995/2000 and 2000/2005 were calculated.
Figure 3 shows the results for individual energy sources. The share of electricity in energy expenditures decreased by 6,6 percent between the two periods. The negative price effect (-7,4 percent) dominates the slightly positive quantity effect in this case. Although real electricity demand had a higher growth rate than total energy expenditures the expenditure share declined due to a reduction in electricity prices[9]).
The expenditure share of natural gas rose by 12,8 percent, caused by a positive quantity effect (+7,3 percent) as well as a positive price effect (+5,2 percent). Thus, the increases in price and real demand were both above average (compared to total energy). This reflects the growing importance of natural gas for heating in the period under consideration. Liquid fuels showed an increase of their share in total energy expenditures by 13,9 percent. The negative real effect – a lower increase than total energy consumption – is contrasted by a high positive price effect (+26,2 percent).
The decline in relative demand for liquid fossil fuels and the strong increase in natural gas suggest the substitution of oil by natural gas. The same conclusion can be drawn for district heating: the positive quantity effect (+2,6 percent) was dominated by a negative price effect (-4,8 percent), leading to a decline of the nominal expenditure share of 2,3percent. Real demand grew faster than total energy consumption, which can also be attributed to the intensified development of district heating networks.
Solid fossil fuels lost in importance, caused by a reduced demand (in real terms) and a below average price development.

[9]) This can be partly interpreted as the effect of electricity market liberalization.

Figure 3: Shift in shares of residential energy expenditures by energy source – quantity and price effects



Source: Statistic Austria, WIFO-calculations.

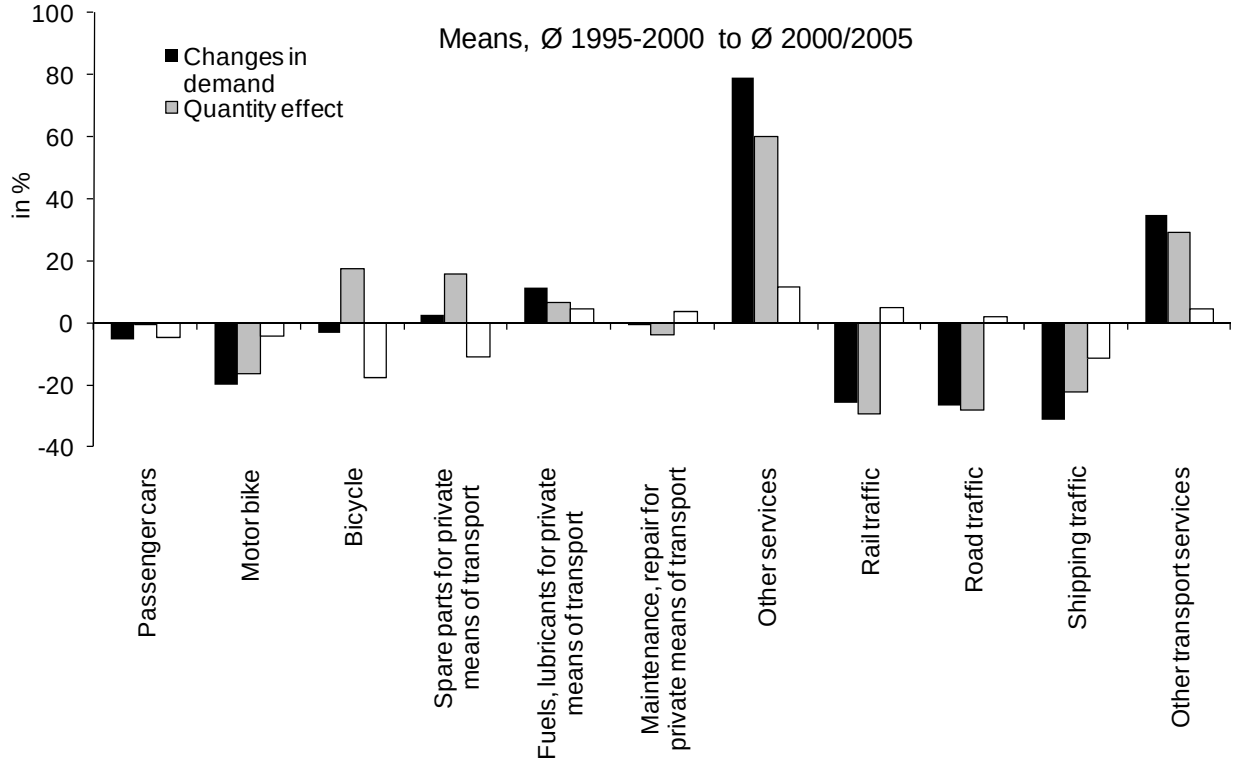
Price and quantity effects for transport were calculated by the same method, using the means for the periods 1995/2000 and 2000/2005 and resulting in shifts in shares of the individual categories in total transport expenditures.

The nominal share of car purchase thus declined by 5,2 percent, due to a below average rise in car prices between the periods. The real demand for cars thus grew slightly slower than total transport expenditures, which is also reflected in a slowdown of growth in car stocks (1990/2000 +3,2%, 2000/2005 +1,6%).

Other relevant expenditure categories for individual car transport are fuels and maintenance. The nominal share of fuels in transport expenditures increased significantly by 11,2 percent. Real fuel demand grew by 6,5 percent and thus faster than total expenditures. This reflects the high rise in energy prices in recent years.

Public transport is characterised by a significant decline in its nominal share in total transport expenditures. Rail traffic declined by 25,8 percent – due to a below average quantity effect (+25,8 percent) combined with a higher positive price effect (5 percent more than for total transport). A similar development took place for public road transport: the rise in real demand was lower than the increase in total transport demand between the two periods.

Figure 4: Shift in shares of transport expenditures by category – quantity and price effects



Source: Statistic Austria, WIFO-calculations.

THE AUSTRIAN CONSUMER SURVEY 2004/2005: TRANSPORT EXPENDITURES ACCORDING TO HOUSEHOLD CHARACTERISTICS

Environmental pressures resulting from transport activities, especially individual car traffic, represent a major problem for environmental and climate policy. The development, i.e. the large increase in transport related emissions is not least determined by consumer preferences. The analysis presented in the following is based on data on household expenditure from the Consumer Survey 2004/2005 and illustrates the correlation between socio-economic household characteristics and transport/mobility expenditures.

According to the Austrian consumer survey on average 16 percent of consumption expenditures are used for transport. The analysis on the household level illustrates the correlation of population density and transport expenditures. Households in areas with high population density spend 347 € per month on transport services, which corresponds to a share of 14,2 percent in total consumption expenditure. In contrast, in areas with low population density average monthly transport expenditures amount to 466 € or 18,2 percent[10]. It can be concluded that individual car transport results in higher fixed and variable costs.

In comparison public transport has a share of 8 percent (high population density) or 2,2 percent (low density) in total consumption expenditure. Households in areas with high population density thus spend three times as much on public transport as households in areas with low population density. Reasons for this are different levels of supply with public transport services including their frequency as well as higher distances that have to be covered outside of agglomerations (e.g. for commuting to work, shopping etc.).

[10] In areas with low population density the supply with public transport services is in general comparably lower.

Table 3: Regional structure of transport expenditures

	Monthly consumption expenditure per household	Monthly household expenditure - transport							
		Total		Car purchase		Maintenance, fuel, accessory		Public transport	
	€	€	In %	€	In %	€	In %	€	In %
Population density									
High	2.454	347	14,2	146	5,9	173	7,1	28	1,2
Medium	2.642	424	16,1	189	7,2	220	8,3	15	0,6
Low	2.557	466	18,2	223	8,7	233	9,1	10	0,4
Total	**2.536**	**409**	**16,1**	**184**	**7,3**	**206**	**8,1**	**19**	**0,7**
Significance	**	**	**	-	**	*	**	**	**
Provinces									
Other Provinces	2.599	440	16,9	205	7,9	221	8,5	14	0,6
Vienna	2.326	304	13,1	116	5,0	156	6,7	33	1,4
Total	**2.536**	**409**	**16,1**	**184**	**7,3**	**206**	**8,1**	**19**	**0,7**
Significance	**	**	**	-	-	**	**	**	**

Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Significance of difference in expenditure: ** statistical significant with a probability value of 1%; * statistical significant with a probability value of 5%. Percent is share in total consumption expenditure.

Another key aspect determining transport expenditures is car ownership (Table 4). Households that do not own a car on average spend 4,9 percent of their consumption budget or 70 € per month on transport[11]). Owning one car raises the consumption share to 16 percent or 417 € per month. Households that own three or more cars spend one fifth of their consumption budget on transport, or twice as much as households with one car (837 €)[12].

Table 4: Transport expenditures by car ownership

	Monthly consumption expenditure per household	Monthly household expenditure - transport							
		Total		Car purchase		Maintenance, fuel, accessory		Public transport	
	€	€	In %	€	In %	€	In %	€	In %
Car ownership									
No car	1.424	70	4,9	13	0,9	33	2,3	23	1,6
1 car	2.537	417	16,4	183	7,2	215	8,5	18	0,7
2 car	3.448	677	19,6	328	9,5	332	9,6	17	0,5
3 cars and more	4.058	837	20,6	410	10,1	414	10,2	13	0,3
Total	**2.536**	**409**	**16,1**	**184**	**7,3**	**206**	**8,1**	**19**	**0,7**
Significance	**	**	**	**	**	**	**	-	**

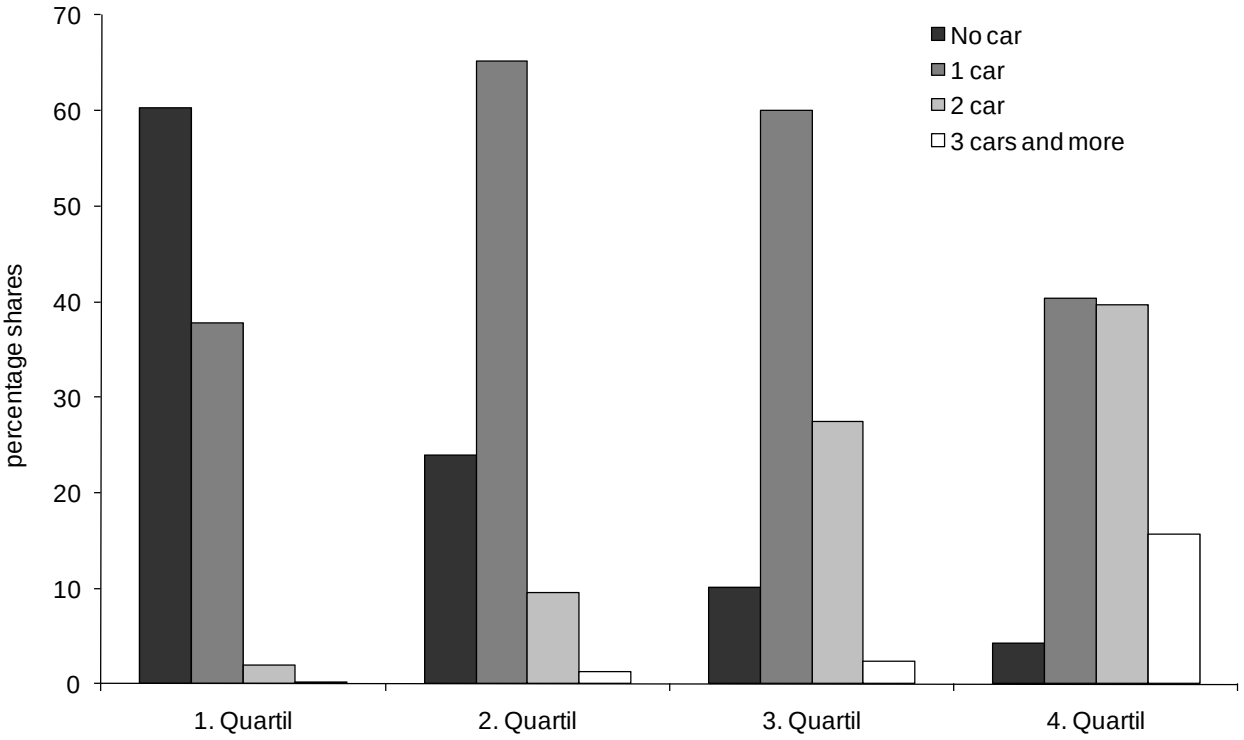
Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Significance of difference in expenditure: ** statistical significant with a probability value of 1%; * statistical significant with a probability value of 5%. Percent is share in total consumption expenditure.

[11]) Expenditure for car purchase in this category could be due to hired cars.

[12] The high absolute expenditures do not equivalently show in the consumption share since the overall level of consumption is higher in these households.

There is a strong correlation between household income on the one hand and the number of cars or monthly transport expenditures on the other hand (Figures 5 and 6). 60 percent of households in the lowest income quartile do not own a car, compared to only 4 percent in the highest income quartile. The number of cars per household rises in line with household income.

Figure 5: Number of cars per household by income quartiles

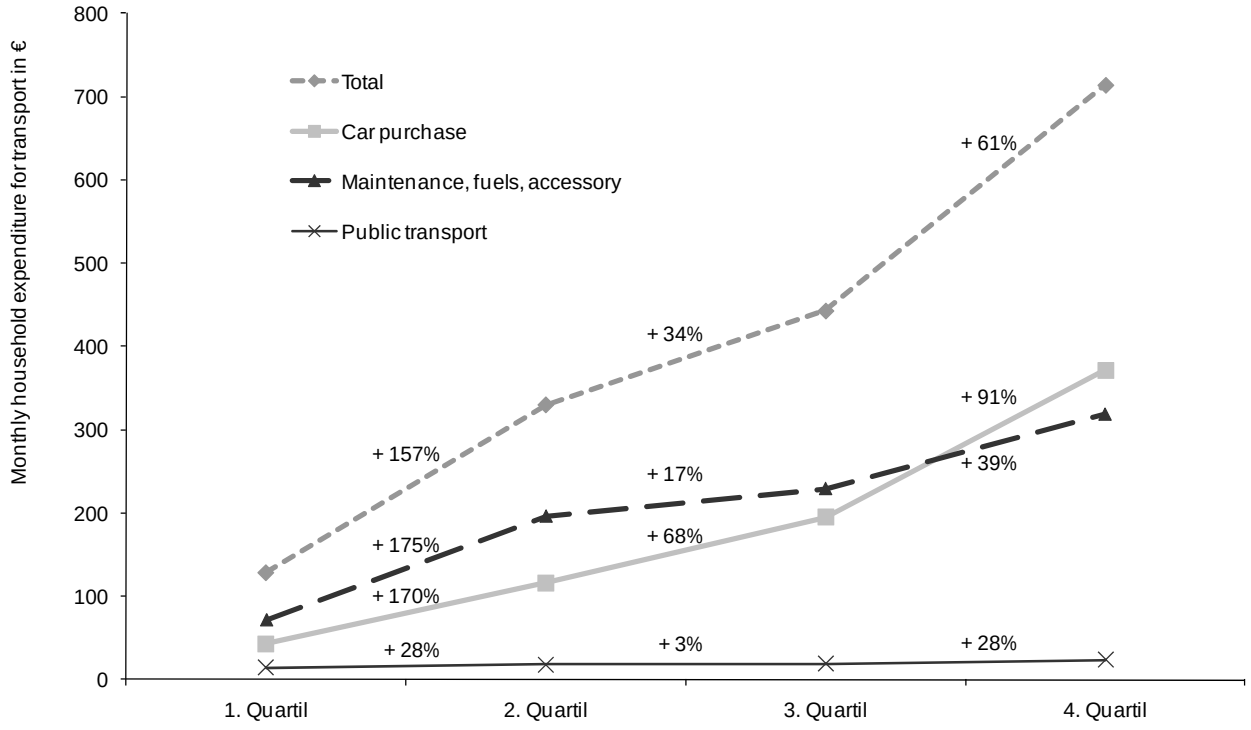


Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations.

In the second income quartile transport expenditures are 157 percent higher than in the first quartile. The difference between the second and the third quartiles is 34 percent. Transport expenditures in the fourth quartile are again 61 percent higher than in the third quartile, amounting to 714 € per month or 5,5 times as much as in the first income quartile. In the highest income quartile 16 percent of households own three or more cars[13], resulting in large expenditures for car purchases in this group. This underlines the role of cars as status symbols and luxury goods. In comparison there is no significant increase in expenditures for public transport between the second and the fourth quartile.

[13] 55 percent of households in this income quartile own at least 2 cars.

Figure 6: Monthly transport expenditures of households by income quartiles



Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations, Data in Percent: Difference between expenditure due to income quartiles.

Table 5: Monthly transport expenditures by income

	Monthly consumption expenditure per household	Monthly household expenditure - transport							
		Total		Car purchase		Maintenance, fuel, accessory		Public transport	
	€	€	In %	€	In %	€	In %	€	In %
Income									
1. Quartil	1.374	129	9,4	43	3,1	71	5,2	14	1,0
2. Quartil	2.120	330	15,6	116	5,5	196	9,2	18	0,9
3. Quartil	2.747	443	16,1	195	7,1	229	8,3	19	0,7
4. Quartil	3.841	714	18,6	372	9,7	318	8,3	24	0,6
Total	**2.536**	**409**	**16,1**	**184**	**7,3**	**206**	**8,1**	**19**	**0,7**
Significance	**	**	**	**	*	**	*	-	**

Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Significance of difference in expenditure: ** statistical significant with a probability value of 1%; * statistical significant with a probability value of 5%. Percent is share in total consumption expenditure.

THE AUSTRIAN CONSUMER SURVEY 2004/2005: ENERGY EXPENDITURES FOR HOUSING ACCORDING TO HOUSEHOLD CHARACTERISTICS

Monthly energy expenditures for housing play a much lesser role than transport expenditures. Their share in total consumption expenditure is less than 5 percent or 20 percent of total costs for housing (including rent, maintenance, fees for waste, water etc.).
As in the case of transport energy expenditures differ regionally. In regions with low or medium population density most dwellings are single family houses, which have a higher specific energy demand for heating than larger, multiple storey residential buildings (lower ratio of surface to building volume). An increased diffusion of energy efficient buildings (low energy or passive houses) and thermal renovations would reduce the difference in energy demand between the types of buildings. However, in Austria on average about two thirds of residential buildings are single family houses.
Households in areas with high population density on average spend 91 € per month on energy, while the expenditure increases to 130 € in areas with medium to low population density. Also, the structure of expenditures in terms of energy sources differs regionally (Table 6). In densely populated areas electricity represents 41 percent of energy expenditures. Heating is largely provided by natural gas or district heating, oil or coal play only a minor role. In areas with lower population density district heating or gas networks are less frequent as they require a certain number of connections per square kilometer to be economically feasible.

Table 6: Regional structure of energy expenditures

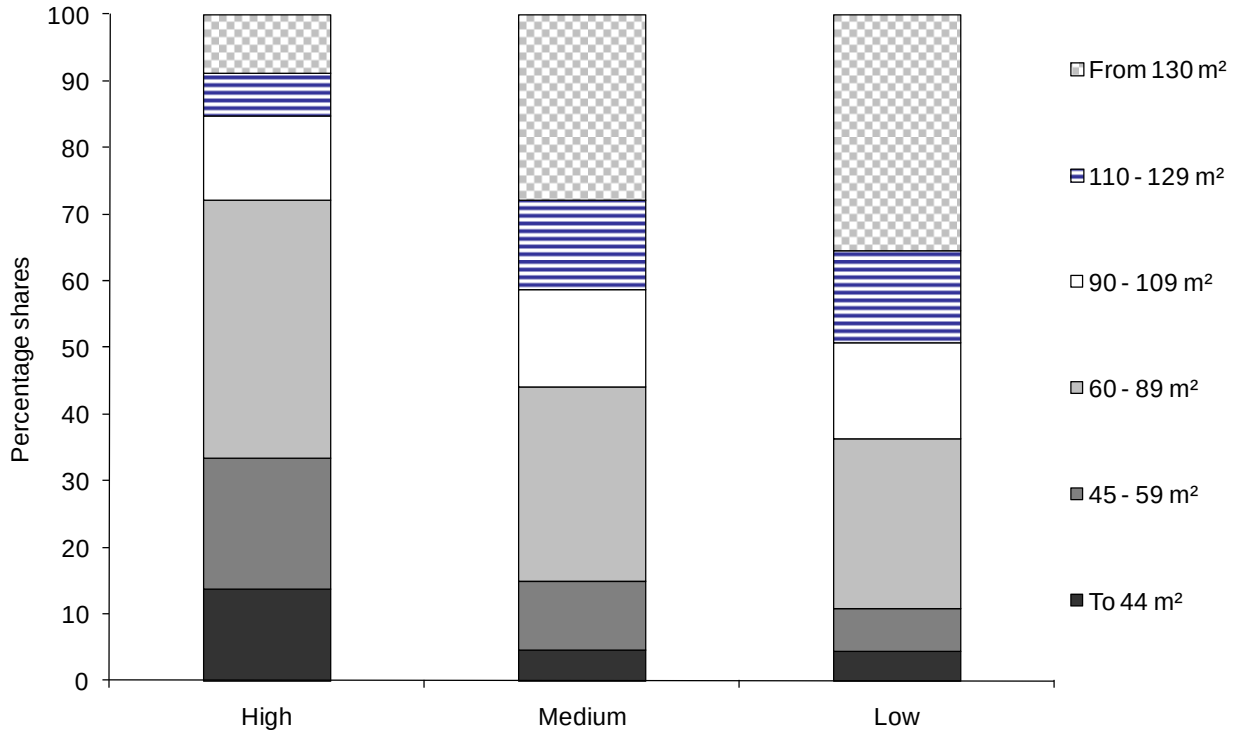
	Monthly consumption expenditure per household	Monthly expenditure for heating/lightening													
		Total		Electricity		Gas		Liquid fuels		Solid fuels		Heat		Others	
	€	€	In %	€	In %	€	In %	€	In %	€	In %	€	In %	€	In %
Populations density															
High	2.454	91	3,7	37	1,5	21	0,9	6	0,3	2	0,1	15	0,6	9	0,4
Medium	2.642	132	5,0	55	2,1	27	1,0	22	0,9	16	0,6	5	0,2	7	0,3
Low	2.557	135	5,3	55	2,2	10	0,4	31	1,2	29	1,1	4	0,2	4	0,2
Total	**2.536**	**117**	**4,6**	**48**	**1,9**	**19**	**0,7**	**19**	**0,8**	**15**	**0,6**	**9**	**0,3**	**7**	**0,3**
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	-	-
Provinces															
Burgenland	2.476	148	6,0	64	2,6	31	1,2	25	1,0	24	1,0	2	0,1	1	0,1
Carinthia	2.399	130	5,4	51	2,1	7	0,3	34	1,4	17	0,7	11	0,5	10	0,4
Lower Austria	2.632	141	5,4	58	2,2	31	1,2	20	0,8	25	1,0	4	0,1	3	0,1
Upper Austria	2.728	131	4,8	54	2,0	20	0,7	21	0,8	22	0,8	8	0,3	6	0,2
Salzburg	2.720	129	4,7	60	2,2	14	0,5	22	0,8	12	0,4	8	0,3	13	0,5
Styria	2.467	121	4,9	45	1,8	7	0,3	27	1,1	21	0,9	12	0,5	8	0,3
Tyrol	2.657	118	4,5	54	2,0	7	0,3	32	1,2	10	0,4	4	0,2	12	0,4
Vorarlberg	2.514	112	4,4	48	1,9	13	0,5	25	1,0	9	0,3	1	0,0	16	0,6
Vienna	2.326	74	3,2	29	1,3	24	1,0	2	0,1	1	0,0	14	0,6	5	0,2
Total	**2.536**	**117**	**4,6**	**48**	**1,9**	**19**	**0,7**	**19**	**0,8**	**15**	**0,6**	**9**	**0,3**	**7**	**0,3**
Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Significance of difference in expenditure: ** statistical significant with a probability value of 1%; * statistical significant with a probability value of 5%. Percent is share in total consumption expenditure.

Figure 7 shows the correlation between living space per dwelling and population density. In densely populated areas about one third of dwellings have up to 60 m^2 living space, 40 percent between 60 and 90 m^2. In areas with medium population density 40 percent of dwellings have a

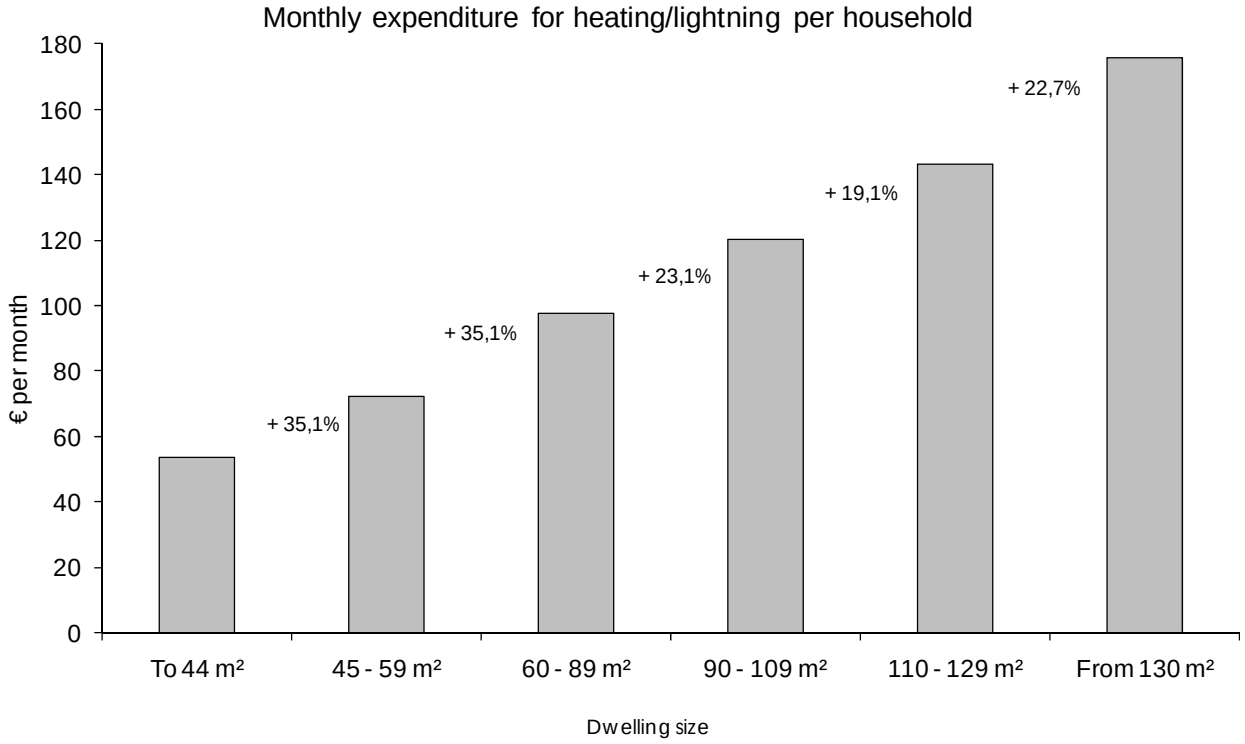
living space larger than 110 m^2, in areas with low population density this share rises to 50 percent. The type of region and the size structure of dwellings thus are relevant factors that explain differences in monthly energy expenditures per household.
Monthly energy expenditures increase with living space (Figure 8). In dwellings with 45 to 60 m^2 energy expenditures are 35 percent higher than in dwellings with less than 45 m^2. The percentage difference to the next size category (60 to 89 m^2) has the same magnitude, while the percentage difference between the higher size categories lies between 20 and 23 percent.

Figure 7: Population density and dwelling size (in m²)



Source: Statistic Austria, consumer survey, 2004/05; WIFO-calculations.

Figure 8: Energy expenditures by dwelling size



Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Percentage information is the difference between expenditure due to dwelling size. The differences in expenditure are statistically significant with a probability value of 1%.

Living space per household and resulting energy expenditures are strongly correlated with income (Table 7). Households in the highest income quartile spend twice as much on energy as households in the lowest quartile (154 € per month compared to 79 €). The variation stems solely from differences in living space as expenditures per m^2 do not differ significantly. Contrary to absolute expenditures the share in total consumption declines from 5,8 percent (1st quartile) to 4 percent (4th quartile). Energy demand, especially for space heating, can thus be regarded as a basic need and consumption does not increase with income as is the case for transport.

Table 7: Energy expenditure for housing by income quartiles

	Monthly consumption expenditure per household	Monthly expenditure for heating/lightening													
		Total		Electricity		Gas		Liquid fuels		Solid fuels		Heat		Others	
	€	€	In %	€	In %	€	In %	€	In %	€	In %	€	In %	€	In %
Income															
1. Quartil	1.374	79	5,8	33	2,4	13	1,0	8	0,6	9	0,7	8	0,6	7	0,5
2. Quartil	2.120	103	4,9	43	2,0	16	0,8	16	0,8	10	0,5	10	0,5	9	0,4
3. Quartil	2.747	127	4,6	52	1,9	21	0,8	23	0,8	16	0,6	9	0,3	6	0,2
4. Quartil	3.841	154	4,0	62	1,6	26	0,7	28	0,7	21	0,6	10	0,3	6	0,2
Total	**2.536**	**117**	**4,6**	**48**	**1,9**	**19**	**0,7**	**19**	**0,8**	**15**	**0,6**	**9**	**0,3**	**7**	**0,3**
Significance	**	**	**	**	**	**	**	**	**	*	**	**	**	**	**

Source: Statistic Austria, consumer survey 2004/05, WIFO-calculations. Significance of difference in expenditure: ** statistical significant with a probability value of 1%; * statistical significant with a probability value of 5%. Percent is share in total consumption expenditure.

ENERGY EXPENDITURES ADJUSTED FOR DIFFERENCES IN INCOME

The main determinants of household energy consumption were described in the previous passages. In order to identify the impact of consumption patterns and lifestyles, the impact of these factors has to be assessed in an unbiased way. A large part of variations in consumption patterns is certainly due to differences in household income. In the following the descriptive analysis presented above is complemented by econometric estimates for elasticities of demand for selected consumption categories. These elasticites indicate to which percentage energy expenditures change when total consumption changes by 1 percent. This allows for conclusions on how households with different characteristics would behave, if income differences (measured as total consumption) were inexistent and helps to isolate the impact of certain household characteristics.

For modelling energy consumption an Almost Ideal Demand System (AIDS) approach (*Deaton – Muellbauer,* 1980) was used[14]). Regarding energy use for housing elasticities for electricity, other energy sources and total energy expenditure were calculated based on the data of the consumer survey 2004/2005. Results show that a rise in total consumption leads to a below average increase in energy demand for housing, i.e. the elasticities are below 1 for all household characteristics and all energy sources. This confirms the conclusion that energy for housing is a daily need and reacts only to a small extent to changes in income.

Elasticities for transport expenditures (car purchase, car maintenance, public transport) were calculated analogously accounting for household characteristics like population density, car ownership etc.

Results show that elasticities are generally higher for transport expenditures than for energy expenditures for housing. For car purchase the elasticities for households that own a car are higher than 1. Elasticities for the other transport categories are below 1.

Differences in elasticities between household types are not very pronounced. Merely households in areas with low population density tend to increase their expenditures on fuels when their income rises, while the opposite is the case for public transport expenditure.

Tables 8 and 9 show the impacts of differences in elasticities on energy and transport expenditures. The actual shares in total consumption as calculated from the consumer survey data (and presented in the previous sections) are compared to the hypothetical shares calculated with the Almost Ideal Demand System approach. Therefore, it was assumed that all households have the same consumption expenditure level (the average consumption expenditure from the consumer survey). The resulting differences in expenditure shares are thus due to determining factors like lifestyles and technologies used.

As shown in Table 8 the actual share of energy declines with rising income[15]). The increase in the share of energy expenditures with living space is not altered by the removal of income differences, in the contrary it becomes more pronounced. Differences in expenditures for energy are only to a lesser extent dependent on levels of income as actual and adjusted shares do not diverge significantly. Thus, the main drivers for housing energy demand are rather technological aspects (thermal quality of buildings) and weather conditions.

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[14]) This approach is rather generally applicable and flexible. Recnetly its advantage compared to other methods has been shown in *Xiao - Zarnikau – Damien (*2007) for explaining electricity demand in the USA.

[15] This result corresponds to the theory of Engel curves that states that with rising wealth in an economy the expenditures for daily needs decline (satiation).

Table 8: Actual shares and shares adjusted to income of energy expenditures in households in total consumption expenditure

	Total energy		Electricity		Sonstige Energie-träger	
	Actual shares in %	Adjusted to income differences in %	Actual shares in %	Adjusted to income differences in %	Actual shares in %	Adjusted to income differences in %
Population density						
High	3,72	3,56	1,52	1,45	2,21	2,11
Medium	5,01	5,30	2,08	2,20	2,93	3,10
Low	5,27	5,33	2,16	2,19	3,11	3,14
Size of dwelling						
To 44 m²	3,79	1,98	1,61	0,84	2,17	1,13
45 - 59 m²	4,20	2,73	1,92	1,25	2,27	1,49
60 - 89 m²	4,38	3,76	1,84	1,57	2,54	2,19
90 - 109 m²	4,39	4,81	1,78	1,95	2,61	2,86
110 - 129 m²	4,90	5,85	1,90	2,27	3,00	3,58
From 130 m²	5,02	7,57	2,02	3,09	3,00	4,47

Source: Statistic Austria, consumer survey, 2004/05, WIFO-calculations.

As shown in Table 9 the adjusted shares of transport expenditures are lower than the actual ones in densely populated. In areas with medium and low population density the inverse effect occurs. The adjustment on the one hand enlarges regional differences for the categories car purchase and maintenance. On the other hand also the influence of the number of cars becomes more pronounced. The expenditure share of public transport in turn is not significantly altered by the adjustment for income differences.

Table 9: Actual shares and shares adjusted to income of transport expenditures in total consumption expenditure

	Transport total		Car purchase		Maintenance, repair of private means of transport		Public transport	
	Actual shares in %	Adjusted to income differences in %	Actual shares in %	Adjusted to income differences in %	Actual shares in %	Adjusted to income differences in %	Actual shares in %	Adjusted to income differences in %
Population denisty								
High	14,16	13,31	5,93	5,46	7,07	6,75	1,16	1,10
Medium	16,05	17,36	7,16	7,90	8,32	8,85	0,58	0,61
Low	18,24	18,54	8,72	8,90	9,12	9,23	0,41	0,41
Car ownership								
No car	4,90	1,95	0,92	0,35	2,34	1,03	1,63	0,56
1 car	16,42	16,44	7,22	7,23	8,50	8,50	0,71	0,71
2 car	19,63	36,90	9,52	21,01	9,62	15,11	0,49	0,77
3 cars and more	20,63	52,42	10,10	29,76	10,21	22,10	0,32	0,56

Source: Statistic Austria, consumer survey, 2004/05, WIFO-calculations.

CONCLUSIONS

Energy use of private households is important from an environmental and climate policy point of view. Energy consumption for housing (heating, lighting etc.) represents 30 percent of total final energy demand in Austria , private households' share in greenhouse gas emissions is 24 percent. But also from an economic perspective energy use is relevant. 21 percent of consumption budgets are on average spent for energy, with the larger part (16 percent) resulting from transport.

The analysis presented in this paper assessed households' energy expenditures based on stylised facts taking into account household characteristics and differences in income. Energy demand for heating is thus mainly determined by population density (choice of area of residence), the type of dwelling (single family house versus multiple storey building) and user behaviour. Households in areas with low population density on average spend 50 percent more on energy than households in densely populated areas. This differences cannot be explained by differences in income, however. The increase in total energy demand is driven by the rise in the number of households and of total living space. The relevant determining aspects are the size, the type and the thermal quality of the building. The latter has been improving over time for new buildings as stricter regulations were introduced, but still a large part of the existing building stock is very energy intensive.

Consumption expenditures for transport are largely determined by individual car traffic which is strongly related to settlement structures. Households in areas with high population density spend 14 percent of their consumption budget on transport while this share rises to 18 percent in areas with low population density. Independent of income car ownership determines the major part of transport expenditures. Although car ownership increases with income and cars play an important role as status symbols it is other aspects like the decision where to live, the respective supply with public transport services and their attractiveness that shape transport behaviour and expenditures.

Since the reduction of negative external effects from energy use (emission of greenhouse gases and other air pollutants, health effects, etc.) is a major target of environmental policy, the findings underline the necessity for an integrated approach to energy, transport and environmental policies. It also shows that in addition to other regulation – like market based instruments related to energy use - the aspects of spatial planning, zoning regulations and building codes are important to consider in this respect.

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