The Structure of Electricity Consumption and its Utilisation Efficiency in the European Transition Countries

Preliminary Communication

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Abstract *– The paper considers end-use electricity consumption and efficiency trends in transition countries, i.e. ten former socialist states that are now new EU members, and the Republic of Croatia as a candidate country. For the last twenty years, transition countries are in the process of changing their social, economic and political structures with considerable influence on the electricity sector. In these former socialist countries, due to a planned economy, the energy sector has been significantly irrational. The paper analyzes efficiency of energy consumption on a national level, electricity intensive branches and especially electricity consumption in the sector of services and households. Efficiency of electricity consumption in transition countries is analyzed and compared with the same indicators of the fourteen developed European countries. Furthermore, the structure of electricity consumption and its utilization efficiency in transition countries and Croatia is presented. Finally, techno-economical solutions are proposed.*

Keywords: *distribution losses, electricity efficiency, electricity consumption, transition countries.*

1. INTRODUCTION

In contemporary conditions, consumption of energy (and electricity) is rationally organized in technological, ecological and economic frameworks of efficiency. Efficiency policies can be applied at different levels, including machine level, business system level, industry branches, economic areas, national economy and the overall state level. On a national level all technical specifications and scientific-technological solutions in the production of energy are summarized. Utilization of energy is affected by climate and cultural conditions, economic and policy measures, and therefore energy efficiency policy is manifested at the country level [1]. Electricity production accounts for 32% of the total global fossil fuel use and around 41% of the total energy-related CO2 emissions. Improving the efficiency of electricity production is therefore one of the most important ways of reducing the world's dependence on fossil fuels, thus helping both to combat climate change and to improve energy security [2]. Therefore, efficient utilization of energy represents an important aspect of all human activities starting from the machine, over a business system and a national economic frame to a global, i.e. planetary, level.

End-use electricity consumption of eleven transition countries, i.e. ten former socialist states, now new EU members, and Croatia is considered in this paper. For the last twenty years, transition countries are in the process of changing their social, economic and political structures with considerable influence on the electricity sector. In these former socialist countries, due to a planned economy, the energy sector has been significantly irrational. The paper analyzes efficiency of energy consumption on a national level, electricity intensive branches and especially electricity consumption in the sector of services and households. Efficiency of electricity consumption in transition countries is an

alyzed and compared with the same indicators of the developed European countries.

Transition European countries (**TEC**) are represented by ten new EU members, i.e. former socialist states and Croatia as a candidate country (see Table 1). Developed European countries (**DEC**) are represented by twelve developed EU member countries and two non-EU member countries, Norway and Switzerland (Table 2). Five EU member countries, (Cyprus, Greece, Luxembourg, Malta and Portugal) are not included in DEC. Thus, the presented analysis differs from EU-27 indicators.

2. ELECTRICITY CONSUMPTION

Developed European countries (fourteen countries) have greater total electricity consumption than transition European countries (eleven countries). Total electricity consumption in 1997, were 2,141 TWh and 300 TWh for DEC and for TEC, respectively. Therefore, due to a large span, it is impossible to clearly present details of basic TEC-DEC relations, and based upon that, there are two parallel analyses in our considerations, see Fig. 1.

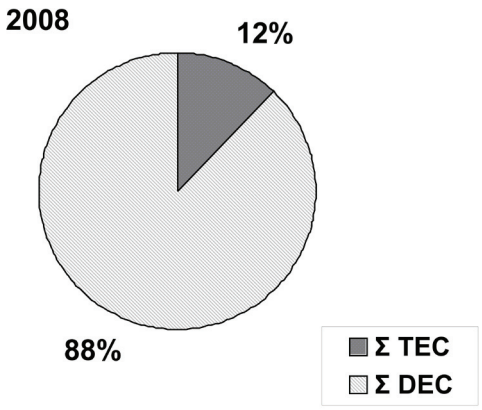

Fig. 1. Final electricity consumption in TEC and DEC in 2008 - TWh. Source: calculated from [3]

2.1. ELECTRICITY CONSUMPTION BY INDUSTRY

Electricity consumption in industry covers all industrial sectors with the exception of the energy sector, like power stations, oil refineries, coke ovens and all other installations transforming energy products into another form [3].

Industry, as an area of economy, is the largest user of electricity. Tables 1-2 and Figures 2-3 show end-use electricity consumption by industry of both European transition and developed countries. Electricity consumption by industry in TEC varies. After a slight drop in consumption (1997-1999), a small growth of 2.9% (2008) is registered at the end of the period. Three countries registered a fall in consumption: the Bulgaria index reached 92.7, meaning that the year 1997 is represented by 100, the Romania index reached 90.6 and the Poland index reached 91.5. The largest growth was annotated by Croatia (index 131), Slovenia (129), the Czech Republic (129) and Slovakia (125), as presented in Table 1 and Figure 2.

Table 1. Final electricity consumption in industry of TEC - TWh. Source [3]

	1997	2000	2002	2004	2006	2008
Bg	11.7	8.6	8.5	9.7	10.0	10.9
Cz	18.5	18.9	20.6	22.4	23.6	23.9
Ee	2.2	1.8	1.9	2.1	2.3	2.3
Hu	8.8	8.8	10.3	9.5	9.4	9.9
Lv	2.8	2.3	2.5	2.7	2.9	2.8
Lt	1.5	1.4	1.5	1.6	1.8	1.7
Pl	48.8	40.5	38.2	42.4	42.8	44.3
Ro	25.1	19.9	22.7	25.2	24.3	23.0
Sl	4.9	5.5	5.8	6.8	7.4	6.3
Sk	10.1	9.7	9.0	10.7	11.9	12.6
HR	**3.0**	**3.0**	**3.1**	**3.5**	**3.7**	**4.0**
TEC	137.5	120.6	124.1	136.7	140.2	141.6

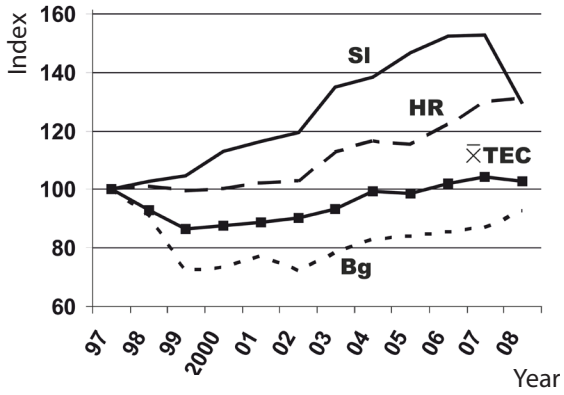

Fig. 2. Final electricity consumption in industry of TEC - (TWh) index 1997=100.
Source: calculated from T1

In the same period, DEC achieved growth of 15.6%; only Denmark recorded a 1.9% drop (index 98.1), whereas the largest growth was registered in Austria, index 150 (base 1997=100) and Spain (148), as shown in Table 2 and Figure 3.

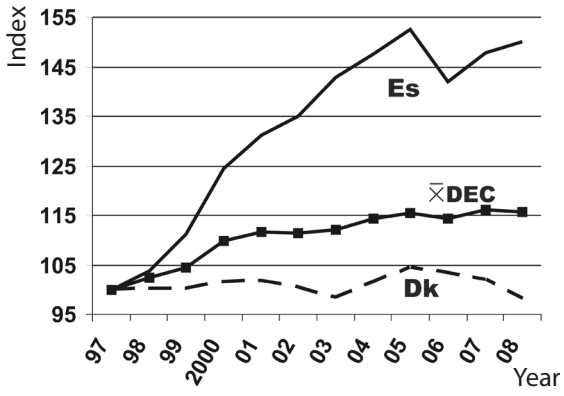

Fig. 3. Final electricity consumption by industry of DEC - (TWh) index 1997=100.
Source: calculated from T2.

The main cause of growth in Croatia is a result of post-war renewal of industry production (a lower level of the base year in statistical considerations). Transition countries are in the process of consolidating the whole

economy after the process of privatization and acceptance of market economy. European developed countries recorded a 22.2% growth as a result of a stable condition of production.

Table 2. Final electricity consumption in industry of DEC - TWh. Source [3]

	1997	2000	2002	2004	2006	2008
At	18.5	20.7	21.6	23.3	26.7	27.4
Be	36.4	39.9	38.9	40.4	40.2	39.0
Dk	9.9	10.0	9.9	10.0	10.2	9.7
Fi	39.5	42.7	43.7	46.1	46.9	43.3
Fr	127.7	134.7	133.4	136.6	134.3	141.2
De	206.3	221.9	233.6	233.8	229.4	242.1
Ir	6.6	7.7	7.8	6.9	9.0	8.0
It	123.5	141.8	143.1	144.2	147.4	141.6
Nl	38.7	40.8	41.4	41.4	41.6	42.2
Es	68.8	85.6	92.9	101.5	97.7	103.3
Se	53.5	56.9	57.3	57.2	57.3	57.7
GB	106.9	114.1	112.6	115.8	117.9	113.6
No	45.8	51.6	47.4	51.2	49.9	50.5
Ch	16.2	18.1	18.1	18.6	19.0	19.3
DEC	898	987	1002	1027	1027	1039

Branches of the textile, iron and steel industry are good representatives of important processes in industries in European countries. Consumption of electricity by the textile industry in the period 1990-2008 in TEC recorded a drop from 9.1 TWh (1990) to 4.3 TWh (2008), index 47 (base 1990=100); Croatia = (index 41). Consumption in DEC decreased from 32.9 TWh (1990) to 29.5 TWh (2008), index 68, as shown in Figure 4.

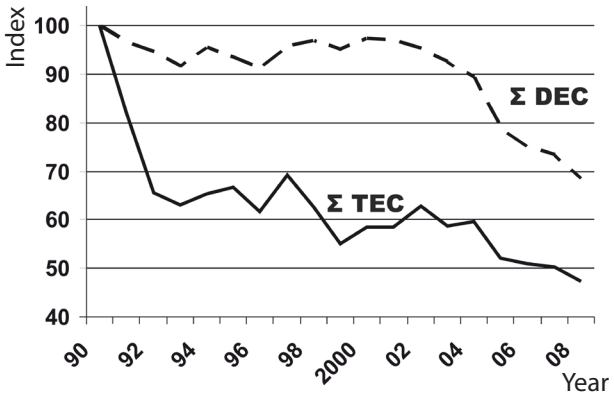

Fig. 4. Final electricity consumption by the textile industry of TEC and DEC – (TWh) index 1990=100. Source: [3]

Decreasing trends are presented in Figure 5. The number of employees in the textile industry in TEC dropped from 353,000 (1990) to 253,000 employees (2008), index 80 (1996=100), and in DEC it decreased from 972,000 to 572,000, index 59. Upon emergence and development of high technologies developed countries abandoned work-intensive manufacturing, and transition countries are not competitive with respect to productivity costs for the same products from Euro-Asian countries and later India and China.

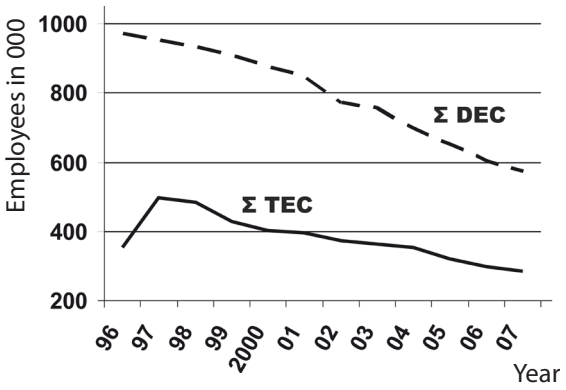

Fig. 5. Number of employees in the textile industry in TEC and DEC – in 000. Source: [3]

The iron and steel industry on the world level undergoes global change. A share of DEC in electricity consumption in the world iron and steel industry dropped from 18.2% (1995) to 12.7% (2005); i.e. in terms of consumption - from 102.9 TWh to 114.6 TWh. A share of TEC dropped from 4.4% (1995) to 2.6% (2005), i.e. in terms of consumption - from 25 to 23.7 TWh, whereas China recorded growth from 90.5 TWh (1995) to 275 TWh (2005), i.e. its world share increased from 16% to 30%, see Fig. 6.

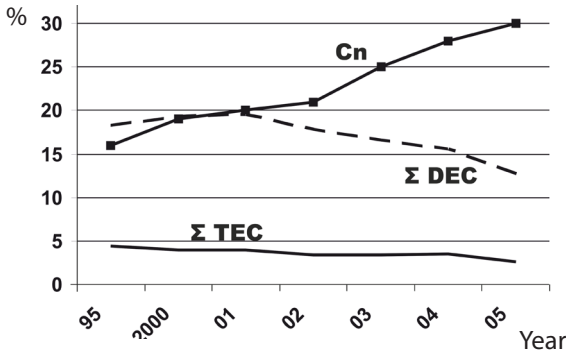

Fig. 6. Final electricity consumption by iron-steel industry in TEC, DEC and China - (TWh) world share. Source: calculated from [4]

A comparison of final electricity consumption by industry in TEC and DEC is shown in Figure 7.

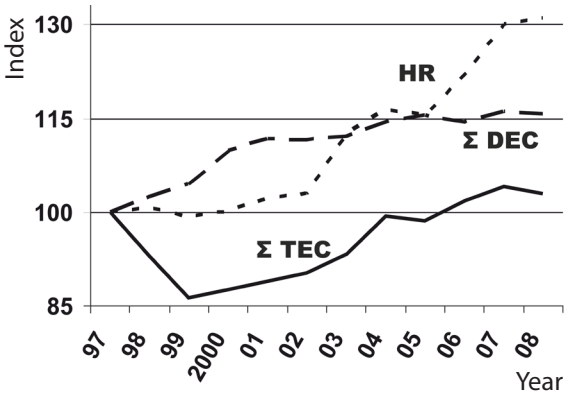

Fig. 7. Final electricity consumption by the industry sector in TEC and DEC - (TWh) index 1997=100. Source: calculated from [3]

2.2. ELECTRICITY CONSUMPTION BY THE SERVICE SECTOR

Final electricity consumption in services covers quantities consumed by small-scale industry, crafts, commerce, administrative bodies, and services with the exception of transportation, agriculture and fishing [3].

Total electricity consumption in services in TEC increased from 47.2 TWh (1994) to 103 TWh (2008). The largest consumption is registered in Poland – from 17.1 TWh (1994) to 41.3 TWh (2008), the Czech Republic – 13.9 TWh (2008) and Lithuania – 10.8 TWh (2008). Other countries are grouped (2008) from 2.6 to 7.1 TWh; e.g. Croatia = 2 TWh (1994) and 5.1 TWh (2008). The highest rate in the period 1994-2008 was registered in Bulgaria; index 501 (1994 = 100) and Romania (328). The smallest growth was recorded in Lithuania, index 147. An average rate for TEC in this period is 218, Croatia = 255, see Fig. 8.

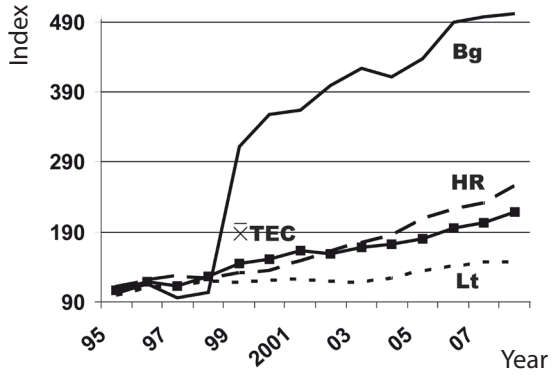

Fig. 8. Electricity consumption by services in TEC - (TWh) index 1994=100. Source: calculated from [3]

Total electricity consumption in DEC services increased from 466 (1994) to 656 TWh (2008), index 141 (1994=100). The largest consumption in 2008 was registered by Germany (118 TWh), France (108), Great Britain (98), Italy (98) and Spain (78 TWh). Other European developed countries are grouped (2008) from 9.6 TWh (Ireland) to 32.8 TWh (the Netherlands). The highest rate in the period 1994-2008 was registered by Ireland, index 277, and Spain (261). The smallest growth was recorded in Sweden, index 109. An average rate for DEC in this period is 141, see Fig. 9.

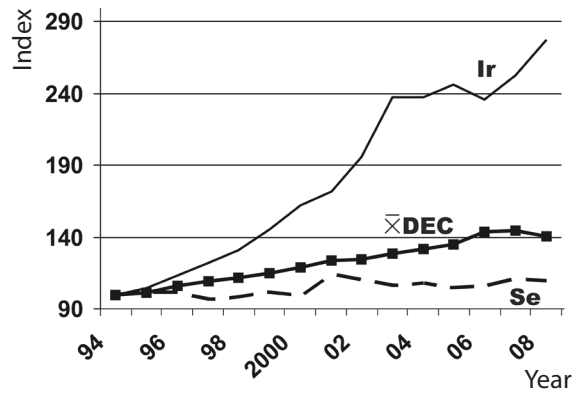

Fig. 9. Electricity consumption by services in DEC - (TWh) index 1994=100. Source: calculated from [3]

In addition to the total consumption measured by energy units and indices, the indicator of electricity consumption in the service sector electricity consumption per employed is important. Figures 10-11 show electricity consumption per employee. This consumption increased in both groups of countries. Average growth of the total consumption in TEC ranges from 3,290 (1995) to 4,584 kWh/emp (2008), index 139. The largest consumption per employee was recorded in Estonia (5,704), and the lowest value was registered in Romania (1,977 kWh/emp). Croatia registered growth from 3,309 (1990), 4,147 (1995) to 5.126 kWh/emp (index 124). An average of the total consumption in DEC increased from 5,769 (1990), over 6,482 (1995), to 6,684 (2004), and dropped to 6,411 kWh/emp (2008), index 125. The largest consumption per employee (2007) was recorded in Norway (11,940 kWh/emp), whereas the lowest value was registered in Germany (3,157 kWh/emp).

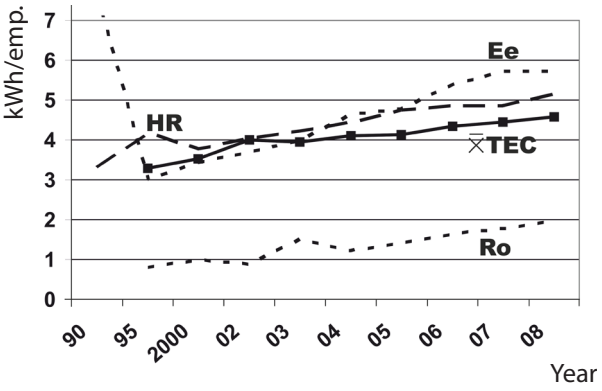

Fig. 10. Electricity consumption of the service sector per employee in TEC - kWh/emp. Source [5]

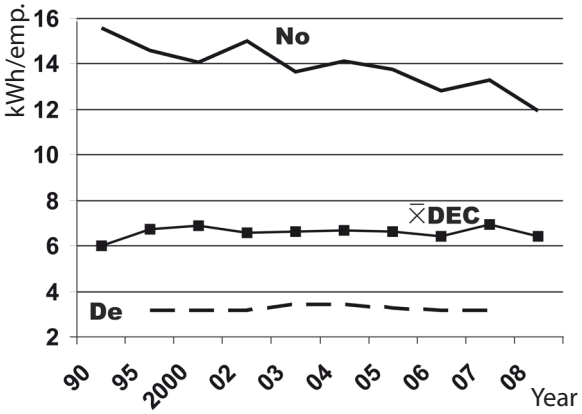

Fig. 11. Electricity consumption of services sector per employee in DEC - kWh/emp. Source [5]

The average electricity consumption by services and its average per employee in TEC and DEC are illustrated in Figure 12. In 2008, TEC registered index 203 (base 1995=100) concerning growth od electricity consumption by services and index 139 concerning consumption per employee. It is greater than the growth of DEC, where index 139 of the average consumption and index 126 of consumption per employee were recorded. Indices for Croatia in this period are as follows: 229 (total consumption) and 124 (consumption per employee).

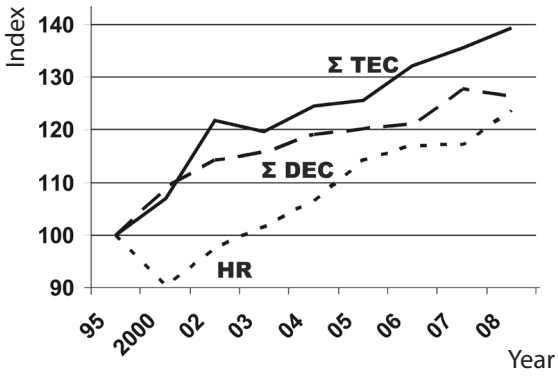

Fig. 12. Final electricity consumption of the service sector per employee in TEC and DEC - (kWh/emp) index 1995=100. Source: calculated from [3], [5]

2.3. ELECTRICITY CONSUMPTION BY TRANSPORT

Final energy consumption in transport covers mainly the consumption by railways and electrified urban transport systems [3].

The following four figures show electricity consumption in transport. As a group of countries, TEC registered a fall in consumption from 12.3 TWh (1997) to 9.5 TWh (2008), index 76.7 (base 1997=100). On the other hand, only three countries registered growth, i.e. Croatia (127), Slovenia (120) and Hungary (116), see Figures 13-14.

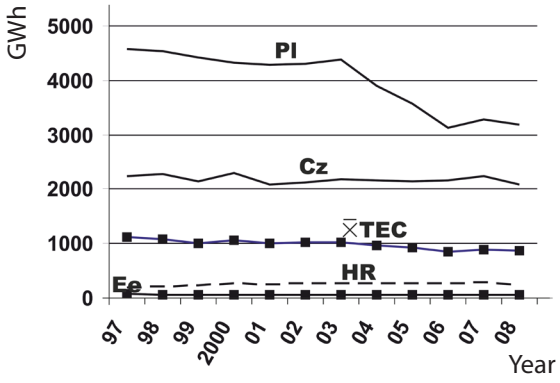

Fig. 13. Electricity consumption by transport in TEC – GWh. Source [3]

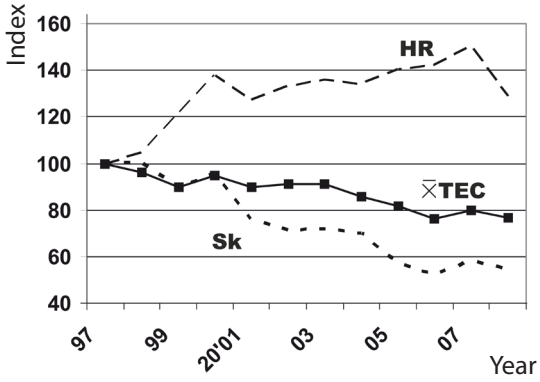

Fig. 14. Electricity consumption by transport in TEC - (GWh), index 1997=100. Source: calculated from [3]

In same period, an average of final electricity consumption by transport in DEC recorded a small increase from 60.3 to 65.2 TWh (index 108). A fall in consumption (2008) was registered in Sweden (index 80), Spain (81), Germany (98), Austria (98) and Great Britain (99). A considerable increase was recorded in Ireland (239) and Finland (148), see Figures 15-16.

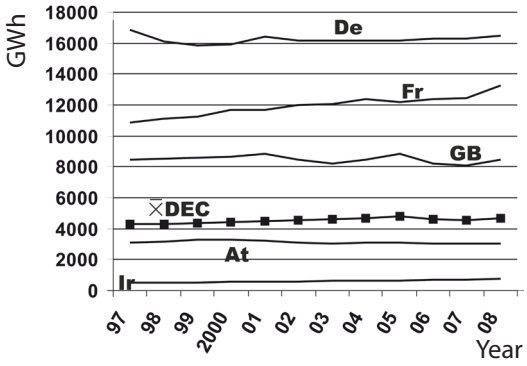

Fig. 15. Electricity consumption by transport in DEC – GWh. Source [3]

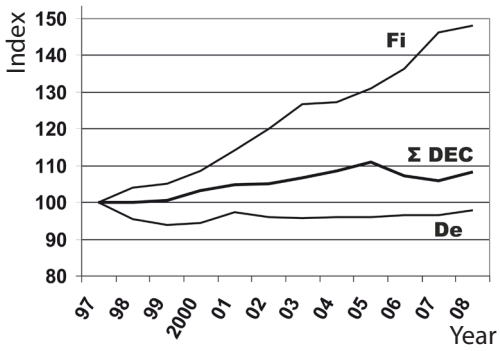

Fig. 16. Electricity consumption by transport in DEC - (GWh), index 1997=100. Source: calculated from [3]

A comparison of the total electricity consumption by transport in TEC (2008) shows a great decrease, index 76.7 (1997=100). On the other hand, small but stable growth and the largest growth are recorded in DEC (108) and Croatia (129), respectively, see Figure 17.

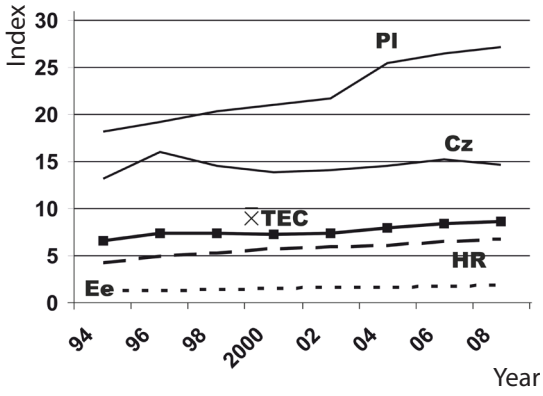

Fig. 17. Final electricity consumption by transport sector in TEC and DEC - (TWh) index 1997=100. Source: calculated from [3]

2.4. ELECTRICITY CONSUMPTION BY HOUSEHOLDS

The indicator is defined as the quantity of electricity consumed by households. Household consumption covers the total usage of electricity for space and water heating, lighting and all electrical appliances [3].

Electricity consumption by households in TEC increased from 72.7 TWh (1994) to 94.7 TWh (2008), index 130. The largest consumption was registered as follows: Poland from 18.2 TWh (1994) to 21.7 TWh (2008), the Czech Republic – 14.7 GWh (2008) and Hungary – 11.5 GWh (2008). The lowest consumption was realized in the following countries: Estonia – 1.85 TWh (2008), Latvia – 2.03 (2008), Croatia – from 4.2 (1994) to 6.7 TWh (2008), see Fig. 18. The greatest rate in the period 1994-2008 was registered in Latvia, index 214, and Lithuania (176). The lowest growth was reported by Bulgaria (102), the Czech Republic (112), and Croatia (159), see Fig. 19.

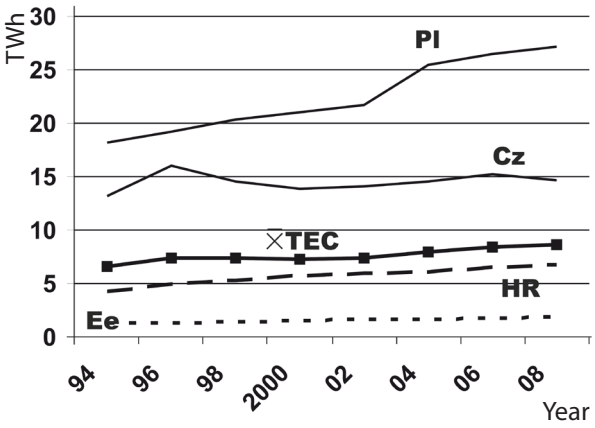

Fig. 18. Electricity consumption by households in TEC – TWh. Source [3]

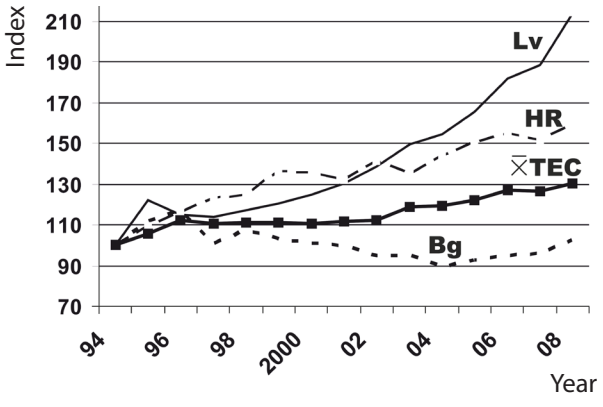

Fig. 19. Electricity consumption by households in TEC – (TWh), index 1994=100. Source: calculated from [3]

The total electricity consumption by households in DEC increased from 605.9 TWh (1994) to 746.5 TWh (2008), index 123. The largest consumption was registered as follows: France - from 111 TWh (1994) to 156 TWh (2008), Germany 139.5 TWh (2008) and Great Britain 117.8 TWh (2008). The smallest consumption (2008) was recorded in Ireland 8.5 and Denmark 10.3 TWh, see Fig. 20. The greatest rate in the period 1994-2008 was registered in Spain, index 207, and Ireland (177). A drop in the rate of growth was registered in Sweden, index 92 (base 1994=100), Belgium (94) and Denmark (99), see Fig. 21.

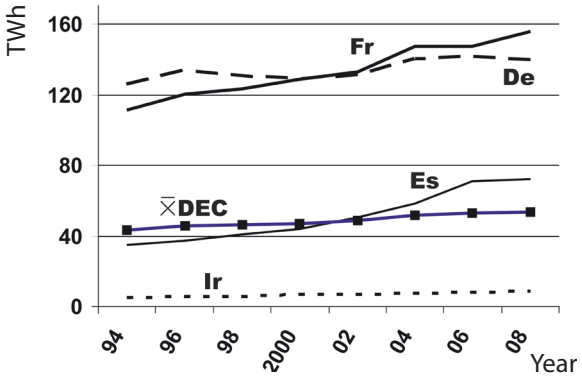

Fig. 20. Electricity consumption by households in DEC – TWh. Source [3]

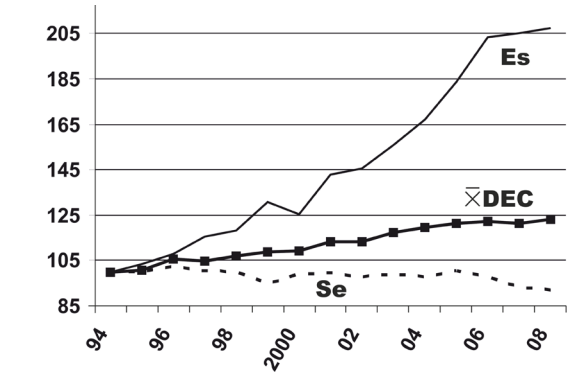

Fig. 21. Household electricity consumption in DEC - (GWh), index 1994=100. Source: calculated from [3]

An average annual consumption of electricity in households per occupied dwelling in transition countries increased from 1,640 to 1,802 kWh/dw. The largest consumption was registered by Slovenia - from 2,343 (1995) to 2,699 (2008), whereas the lowest consumption was recorded by Estonia – 1,048 (2008), and Croatia – from 1,917 (1995) to 2,472 kWh/dw (2008), see Fig. 22.

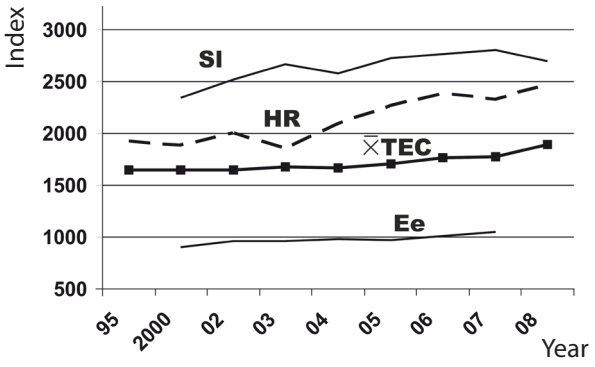

Fig. 22. Electricity consumption for electrical appliances and lighting per permanently occupied dwellings in TEC - kWh/dw. Source [5]

An average electricity consumption in households per dwelling in developed European countries increased from 2,277 to 3,036 kWh/dw. The largest consumption was registered in Finland - 5,800 kWh/dw (2008), while the lowest consumption was recorded in Spain – 2,232 kWh/dw (2008), see Fig. 23.

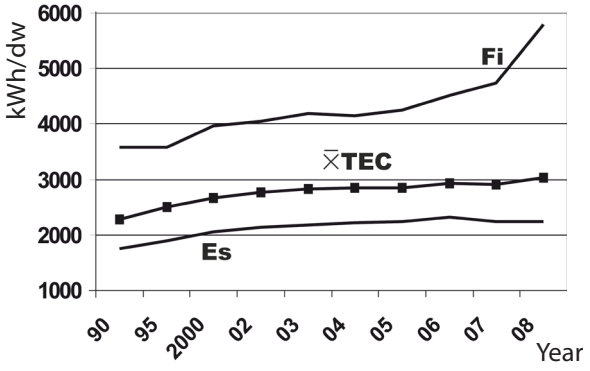

Fig. 23. Electricity consumption for electrical appliances and lighting per permanently occupied dwellings in DEC - kWh/dw. Source [5]

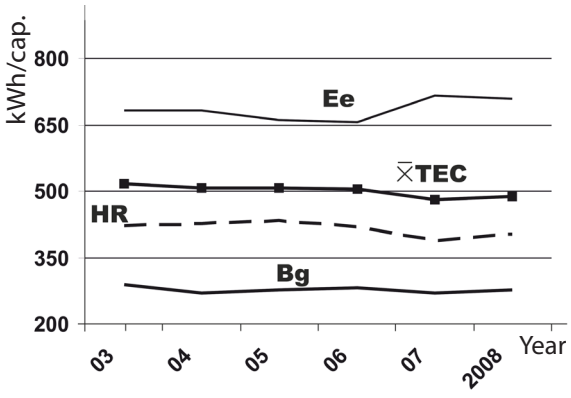

Fig. 24. Electricity consumption in households per capita in TEC - kWh/cap. Source [6]

Electricity consumption in households per capita in TEC decreased from 518 kWh/cap (2003) to 487 kWh/cap (2008), index 94.2 (2003=100). The largest consumption and the smallest consumption (2008) were recorded in Estonia (719 kwh/cap) and Bulgaria (278), respectively. Only four countries registered a small increase in the period 2003-2008, the largest being recorded in Estonia (index 104). The greatest decrease was registered in Slovakia (index 75.5) and Hungary (84.7); cf. Croatia (95.5), see Fig. 24.

Electricity consumption in households per capita in DEC fell from 750 kWh/cap (2003) to 713 kWh/cap (2008), index 94.2 (2003=100). The largest and the smallest consumption (2008) were reported from Finland (942 kwh/cap) and Italy (278), respectively. Only three countries registered a small increase in the period 2003-2008, the largest being in Spain (index 105), Ireland and Germany. The greatest decrease was recorded in Belgium (index 86.1) and Spain (87.6), see Fig. 25.

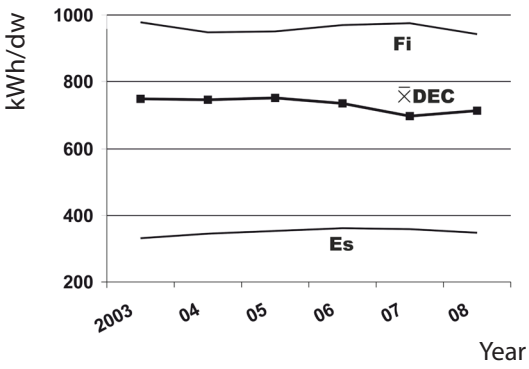

Fig. 25. Electricity consumption in households per capita in DEC - kWh/cap. Source [6]

2.4.1. NEW APPLIANCES IN HOUSEHOLD USAGE

Electricity use grows at almost the same rate as the economy (GDP). Increasing electricity demand is due to many different factors, including:

- More penetration of "traditional" appliances (e.g. dishwashers, tumble driers, air conditioners, personal computers, which are all still far away from saturation levels);
- Introduction of new appliances and devices, mainly consumer electronics and information and communication technology (ICT) equipment (Set-Top boxes, DVD players, broadband equipment, cordless telephones, etc.), many with standby losses;
- Increased use of "traditional" equipment: more hours of watching TV, more hours of using personal computers (driven by some tele-working and increased use of internet), increased use of washing machines and hot water;
- Increased number of double or triple appliances, mainly TVs and refrigerators/freezers;
- More single-family houses, each with some basic appliances, and larger houses and apartments. This results in more lighting, more heating and cooling, and last but not least, older population demanding higher indoor temperatures and all-day heating in winter and cooling in summer, and spending more time at home [7].

From studies [7] and [8], results of technical developments of house appliances which have influenced the level of electricity consumption are introduced.

Refrigerators

Appliances below class B have almost disappeared from the market, registering only a 2.4% and 1.4% market share in DEC and TEC, respectively. The current minimum energy performance standards (MEPS) entered in force in 1999 banning class D or below.

The energy efficiency index (EEI) of cold appliance sales improved continuously between 1993 and 2007, reaching a remarkable 44% efficiency improvement

over the last 14 years. It is also interesting that in 2007 the EEI of the market sales of cold appliances in TEC overtook that in DEC. The explanation resides in a high replacement rate of cold appliances registered in TEC, around 30% in the last 4 years, according to GfK studies.

With energy labelling and minimum efficiency requirements in force since 1994 and 1996 respectively, domestic refrigerators and freezers are one of the success stories of Community energy efficiency policy. Over the last 15 years, an energy efficiency improvement of almost 45% has been achieved, and the EU Energy Label has become one of the most important market drivers. Despite a population growth of 15% over the same period, the absolute energy consumption of domestic cold appliances in 2007 is currently 15% lower than in 1990. In the same period, the industry has practically phased out CFCs and HCFCs and substituted them by hydrocarbons, thus diminishing the Ozone Depletion Potential and the Greenhouse Gas impact of the refrigerant and foaming agents.

Estimated savings of 6 TWh/year within the EU-27 are expected by 2020, when the energy labelling and performance requirements for fridges and freezers reach their full impact.

Washing machines

Washing machine stock has reached saturation, reaching penetration rate levels around 100% in all the EU-27 countries. In TEC, the existing stock was lower than in DEC, but it grew fast reaching the same saturation level as in the rest of EU in almost all the countries from the region.

The EU-27 washing machine stock in the residential sector was estimated to be around 172.85 million units. According to the Eco-design preparatory study for wet appliances, the estimated energy consumption of the washing machine stock in 2005 was around 51 TWh/yr, with 295 kWh of average yearly energy consumption per appliance and a 90% penetration rate in the EU-27 households. Taking into consideration that the market has already reached a saturation level, as well as a growing penetration rate of efficient washing machines in TEC due to a high substitution level, energy consumption remained almost constant in 2007, at around 51 TWh/yr. As in the case of refrigerators, the washing machine market is characterized by a high level of substitution of old appliances, rather than increasing the household stock. Efficiency improvement continues mainly due to an increase in awareness regarding energy consumption, the energy label contributing to a real market transformation across EU-27. In the period from 2002 to 2007, washing machine sales were dominated by class A, with A and A+ classes together taking in 2007 a share of 96.7% and 95.3% in DEC and TEC, respectively. In the countries observed by the GfK panel, the A+10 class share has been rapidly growing, reaching 39% in DEC and 40% in TEC in 2007. Appliances below class B have almost disappeared from the market, registering less than 2% market share on both DEC and TEC markets. According to the GfK panel, for washing machines the attention of the consumer to efficient energy consumption appliances is much higher than for refrigerators and the price seems to be an important element in supporting the growth of segments A+.

Energy labelling and minimum energy requirements for washing machines are expected to deliver savings of 2 TWh/year within the EU-27 by 2020, when these policy tools reach their full potential. On the other hand, behavioural measures, most importantly lowering the washing temperature, could still contribute with important savings.

Dishwashers

In the EU-27, dishwashers have a lower saturation level than major appliances (refrigerators and washing machines). Penetration differs from country to country and it is around 50-60% at maximum. The EU-27 dishwasher stock in the residential sector was estimated at around 69.3 million units. According to the Eco-design preparatory study for wet appliances, the estimated energy consumption for the dishwasher stock in 2005 was around 18.75 TWh/yr, considering a 270 kWh average yearly energy consumption per appliance. The sales for dishwashers in EU-27 are at more than 6 million per year, increasing significantly over the last years by more than 10% on DEC and by around 50% on the TEC markets. The majority of dishwasher models placed on the market in 2005 had a capacity of 12 and 9 place settings and this trend continued also into the next two years. The A energy class dishwashers dominated the EU market in 2007, with more than 92% of the sales being in this category. Appliances below B class have almost disappeared from the market, registering less than 2% market share. For dishwashers there was only relatively small efficiency progress between 2001 and 2005. In 2003 the average consumption per test cycle wash of a 12-place setting dishwasher was 1,197 kWh: down by 10% from the average consumption in 2001. The best model on the market (already for some years) has an EEI of 1.05 kWh per wash cycle. This indicates that even with the present technology, there is no large energy saving potential due to technological progress. This also indicates that there is no possibility to introduce an A+ class. The main energy efficiency measures proposed for dishwashers include imposing the current energy class B as a minimum requirement from 2010, and the current energy class A as a minimum requirement from 2015. By 2020, when the energy labelling and the minimum energy requirements for washing machines reach their full impact, savings of 2 TWh/year are estimated within the EU-27.

Cooking Appliances

Electric ovens represent 97% of the ovens sales in DEC in 2005, with similar trends in TEC. For free-standing cookers the share of electric one is 34.5% and for

gas ones it is about 44%. It is also interesting to notice that for hobs the share in sales among electric and gas is 58.4% and 37.4%, respectively, with almost 100% of electric hobs in Germany and Sweden, and almost 100 % of gas hobs in Italy. Hobs represent 43% of the total sales in DEC and about 20% in TEC, followed by ovens with 26% and 13%, respectively, and 26% and 66% for free-standing cookers. This does not include microwave ovens which have increased penetration, but are not yet used to cook major meals. The total electricity consumption for electric cooking is estimated to be of around 60 TWh (electric hobs and electric ovens together). The impact of the energy labelling started to be visible on the market and the A class appliances represent more than 50% of the EU market. Comparing to the 2005 status, TEC markets had a positive change from less than 40% share of the A class appliances to almost 60% share in 2007. For cooking appliances, there is still an important potential for energy savings that could be exploited in the next future by related national and EU policies.

Dryers

Dryers are the appliances where little progress in energy efficiency has been achieved with the mandatory energy label. In theory, gas heated and heat pump dryers (most of them are in A class and tend to be much more expensive than conventional models), which use much less primary energy, are already on the market, but have almost no market share (with the exception of gas dryers in the UK). Transforming the dryer market to A-label machines will save a lot of energy: for the Netherlands alone calculated savings would be in the magnitude of 0.8 PJ per year. According to GfK, the market sales of domestic tumble dyers are dominated by C class appliances (above 70%), the B class share being more important on TEC markets.

Space heating and boilers

The space heating equipment is still the largest electricity consumer, with an estimated consumption of around 150 TWh/year, including electrical equipment (electric boilers and radiators), monitoring and control equipment of other heating equipment fuelled by gas or oil. The EU central heating stock rose in the last years reaching an estimated 80% of the installed heating systems (some 163 millions dwellings) in 2007. The fastest growth was registered by individual hydronic heating systems – 52-53% from 1990 until the present day – reaching almost 100 million units. Gas-fired systems account for the biggest share of the individual central heating sector (almost 80%). 75% of gas-fired systems are wall-hung ones. The electric central heating boilers represent around 1.2% (1.11 million units) of the existing stock and 0.5 – 0.6% (39,000 units) of the market sales. Apart from individual hydronic central systems, around 10% of the residential stock is connected to the district heating, from which 3% is in TEC. Other 15% represent collective heating and 7% dry electric or gas heaters (room heating). The market trends indicate that electric boilers will also preserve their marginal position in the future. The overall residential boiler sales registered some 7 million units sold in 2007, out of which 60% represent replacements of old existing boilers, 22% for new houses and only some 14% representing first-time installation in a dwelling. The wall-hung gas boilers dominate the stock (51.5%) and the sales (80%), but the biggest part is still taken by non-condensing boilers. In the Netherlands, Germany, UK and Denmark condensing boilers, which represent a more efficient alternative, have significant shares in both the existing stock and market sales. Several countries like France, Ireland, the Netherlands, Austria, Italy and Denmark, have developed specific national programmes offering subsidies and tax credits for high efficiency condensing boilers.

Cooling

Based on the findings of the preparatory study and on ProCom database, JRC estimates that around 2.6 million units were sold in 2007 on the EU-27 market, contributing with more than 10% to an existing stock of around 24 million air-conditioning systems, equivalent to a 100GW cooling capacity. In 2007 the overall electricity consumption of the EU-27 air-conditioning stock was around 17TWh. With the introduction of energy labels for air-conditioning, the EU market has seen a positive transformation into a more efficient one with A class systems sales growing by 361% from 2005 to 2008 on the main EU markets. At same time, the sales for air-conditioning systems, below or equal to C class, diminished more than twice, from 78.4% to 33% and the unknown/not labelled systems sales decreased by some 40%.

Water heater

Electric water heaters are responsible for a considerable share of the total residential electricity consumption (9% in DEC and about 7% in TEC) or around 68.7 TWh/year in 2007. Electric storage water heaters, with a capacity of over 30 litres, represent about 27% of the installed park for primary water heaters, with an additional share of 6.6 % for instantaneous electric water heaters (>12kW) as a primary installation and around 7% of instantaneous water heaters (<12kW) as a secondary one.

Residential lighting

Lighting represents 10.5 % of the residential electricity consumption, being the third main consumer after electricity for heating and cold appliances. Household lamp technologies include incandescent lamps (GLS), halogen lamps, self-ballasted compact fluorescent lamps, and to some extent, also single and double-capped fluorescent lamps without integrated ballast and high intensity discharge lamps. These technologies include also control gear and luminaries designed for these lamps.

Table 3. Sales of CFL lamps. Source ELC 2004 [8]

Year	2000	01	02	03	04	05
Western Europe						
CFL-I	101	109	119	131	145	146
CFL-NI	72	78	80	82	87	92
Central and Eastern Europe						
CFL-I	14	21	27	34	41	
CFL-NI	9	10	12	13	15	

Compact Fluorescent Lamps (CFLs) represent one of the most efficient solutions available today for improving energy efficiency in residential lighting. The recent drop in price, together with several information and promotion campaigns, had a positive impact on sales. Table 3 gives a more accurate insight into the present status of lighting consumption and CFL penetration in households in DEC countries, as well as new TEC. The table shows that there is still a large number of households in the EU-27 which do not own a CFL; moreover, only a few countries show a number of CFLs close to the cost-effective saturation level (about 25% of lighting points per household using a CFL).

Information and communication

Electricity consumption of TVs in 2007 in EU-27 is estimated at 60 TWh, of which 54 TWh in on-mode power consumption and 6 TWh in stand-by/off-mode power consumption. Following the findings of the preparatory study for the Eco-design Directive, JRC estimates indicate that the installed stock of TVs in the EU-27 residential sector is around 310 millions units. The penetration rate of around 150% reflects the market tendency towards 2 TVs per household. Expectations are that equipment for the reception, decoding and interactive processing of digital broadcasting and related services will contribute substantially to the electricity consumption of EU households in the near future. Taking into consideration the penetration level, equipment specifications and service provider requirements, a total European consumption of up to 10 TWh/yr is attributed to STBs [8].

2.4.2. STRUCTURE OF RESIDENTIAL ELECTRICITY USAGE

The final electricity consumption of the residential sector for EU-27 has grown by 13.17% in the period 1999-2007, from 707.5 TWh in 1999 to 800.7 TWh in 2007 and by 2.1% in the period 2004-2007. However, the consumption growth was lower than the economy growth of 20.6% during the period 1999-2007 and 8.2% in the period 2004-2007 (GDP market prices, 2000 exchange rates). For the very first time, in 2007 EU-27 electricity residential consumption went down, decreasing by 7.5% as compared to 2006 [8].

The structure of residential electricity consumption in European countries is shown in Figures 26-29.

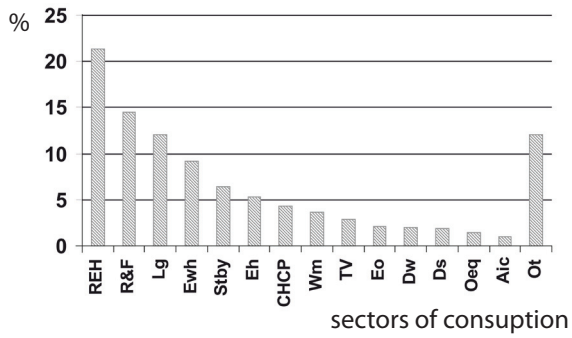

Fig. 26. Structure of residential electricity consumption yr 2004 in EU-15 - %. Source: calculated from [9]

The structure of residential electricity consumption is dynamic in all countries; this structure was influenced by climate, seasons and variations, economic processes and technology progress.

The largest part of electricity consumption in residential electricity used in households of EU-15 in 2004 is heating (21.3%), after which there follow refrigerators and freezers (14.5%) and lighting (12.1%); see Fig. 26.

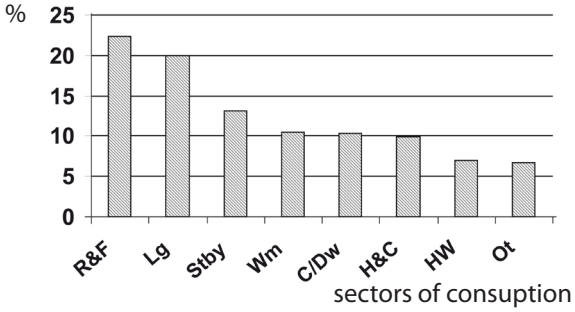

Fig. 27. Structure of residential electricity consumption in 2003 in NMS12+Hr (%). Source: calculated from [10]

The concept of a breakdown by residential electricity consumption in the (12) new EU member states and Croatia, as candidate countries, slightly differs with respect to the number of subsectors under consideration; refrigerators and freezers come first (22.4%) and stand-by appliances consumption is second (20%); see Fig. 27.

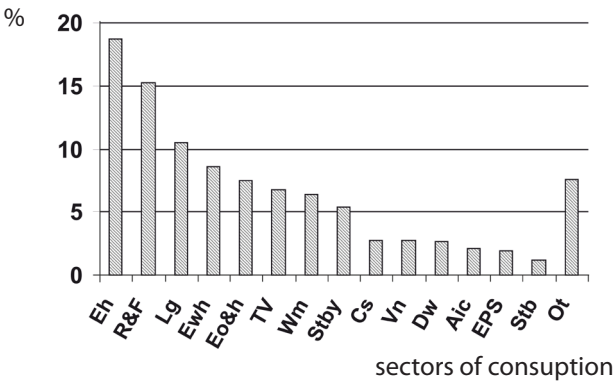

Fig. 28. Structure of residential electricity consumption 2003 in EU-27 in 2007 (%). Source: calculated from JRC [8]

2.4.3. RESIDENTIAL ELECTRICITY USAGE IN CROATIA

Electricity consumption increases in the total energy residential usage in Croatia; see Fig. 29.

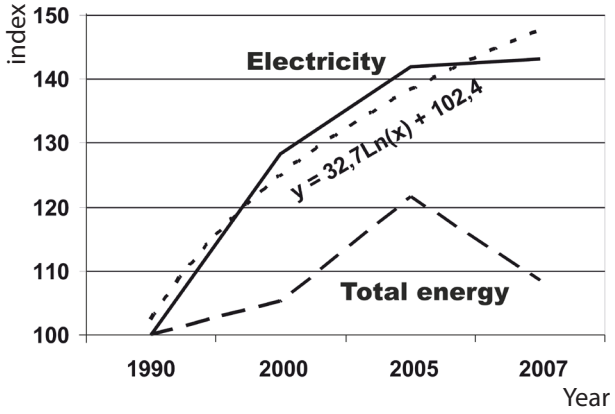

Fig. 29. Electricity and total energy consumption by household in Croatia - index 1990=100). Source: calculated from [11]

Usage of final energy forms in Croatian households increased from 66.2 PJ (1990) to 71.8 PJ (2007), and electricity increased from 16.1 (1990) to 23.0 PJ (2007). The share of electricity consumption in the total final energy consumption in households increased from 24.3 % (1990) to 32.0% (2007); the linear trend equation reads: y = 2.1941x + 23.074; see Fig. 30.

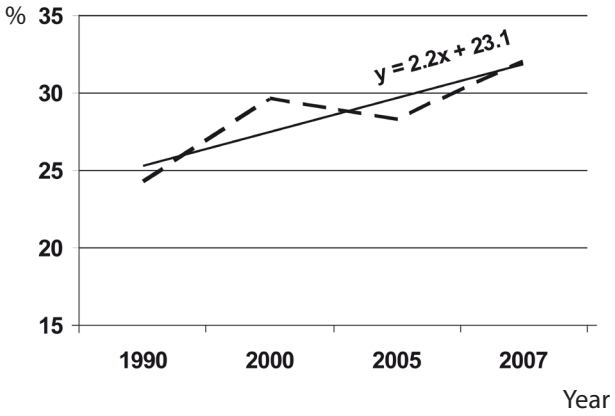

Fig. 30. Share of electricity consumption by household in the total final electricity consumption in Croatia - %. Source: calculated from [11]

Household electricity consumption in Croatia is larger than the average TEC consumption (Fig. 31) and Croatian household consumption is larger than the TEC average of households per occupied dwellings (Fig. 22).

Linear trend lines from key years for TEC (y = - 0.1x + 29.4) and for Croatia (y = - 1.8x + 49.9) show that the 2015 share of households consumption in Croatia will be equal to the average share in TEC.

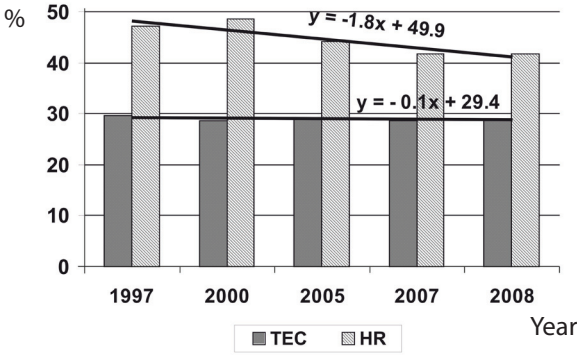

Fig. 31. Share of electricity consumption in the total energy consumption by households in Croatia and TEC average - %. Source: calculated from [3]

2.5. TOTAL OF END-USE ELECTRICITY CONSUMPTION

The total of end-use electricity consumption covers all quantities consumed in a country frame. In our summary consideration analyses 5 main sectors of consumption are industry, transport, services, households and other sectors - which includes consumption by agriculture, fisheries and other (small) sectors, i.e. the rest of different small consumers.

Other consumption sectors, with agriculture and fisheries and the rest of different small consumers, are small and not important for a detailed analysis. Other sector consumption in TEC dropped from 5.4% (1997) to 2.17% (2008) and in DEC it varied from 1.9 to 2.4% of final consumption. In statistical records, a lot of countries in the sector of agriculture and fisheries do not present electricity consumption because it is recorded in the industry or other services sector.

Transition European countries registered the total end-use electricity consumption from 300 TWh in 1997 to 357 TWh in 2008, index 119 (1997=100). Developed European countries recorded growth from 2,141 TWh in 1997 to 2,568 TWh in 2008 (index 120); the linear trend equation reads: TEC y=57x+243, DEC y = 427c +1712; see Fig. 32.

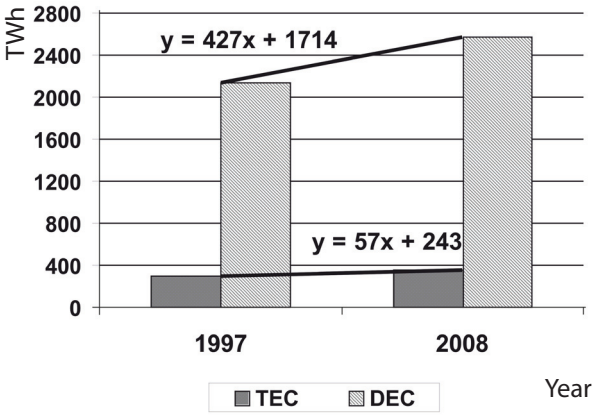

Fig. 32. Total end-use electricity consumption in TEC and DEC – TWh. Source: calculated from [3]

Dynamics of end-use consumption of electricity by several sectors in the period 1997-2008 is shown in Fig. 33. The following might be concluded:

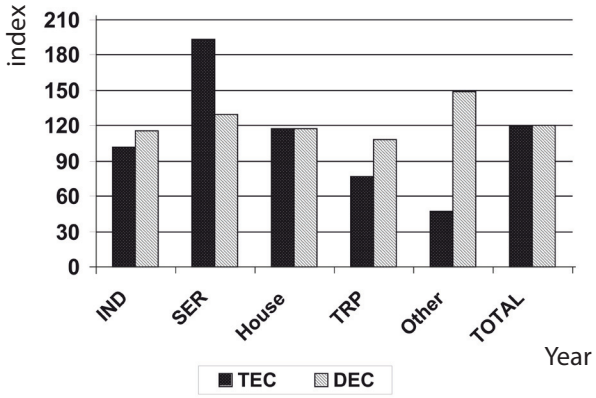

Fig. 33. Dynamics of end-use electricity consumption by several sectors in the period 1997-2008 in TEC and DEC – index 1997=100. Source: calculated from [3]

- Consumption by industry: in TEC during the period 1997-2008 recorded a small growth of 2.2% (index 102.2 on the base 1997 = 100); whereas industry in DEC recorded a larger growth: 15.7% (index 115.7);
- Consumption by services: a growth of 94% (index 194) and 29.2% was registered in TEC and DEC, respectively;
- Consumption by transport in TEC dropped by 23.4% (index 76.6), in DEC there was a growth of 8.15%;
- Consumption by households recorded growth both in TEC (17.9%) and DEC (17.7%);
- Consumption in other sectors in TEC was decreased by 52.5% (index 47.5), whereas DEC reported a growth of 151% (index 251).

The structure of the total end-use electricity consumption and their dynamics for TEC and DEC are shown in Figures 34-35.

- Consumption by industry in TEC during the period 1997-2008 recorded a drop in the structure of the total consumption from 45.9% to 39.7%. The share of the total industry consumption in DEC recorded a drop from 42.0% to 40.5%;
- Consumption by services in TEC increased from 17.8% to 28.9% of the total consumption; whereas in DEC it grew from 23.7% to 25.6%;
- Consumption by transport in TEC dropped in the structure of the total consumption from 4.1% to 2.7%; while in DEC it fell from 2.8 to 2.5%;
- Consumption by households in TEC decreased from 26.8% 26.6%, and in DEC there was also a slight decrease from 29.6% to 29.1%;
- Consumption in other sectors in TEC dropped from 5.4% to 2.1%; whereas in DEC it increased from 1.9% to 2.4%.

Total electricity consumption per inhabitants

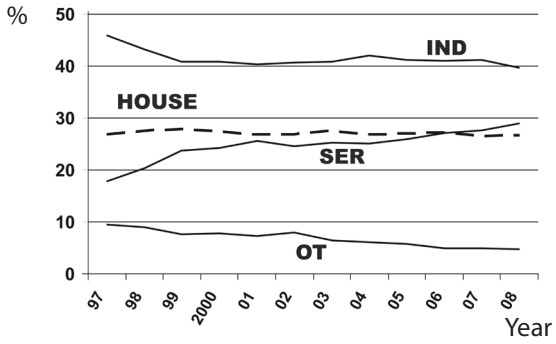

Fig. 34. Structure of the final electricity consumption in TEC - %. Source: calculated from [3]

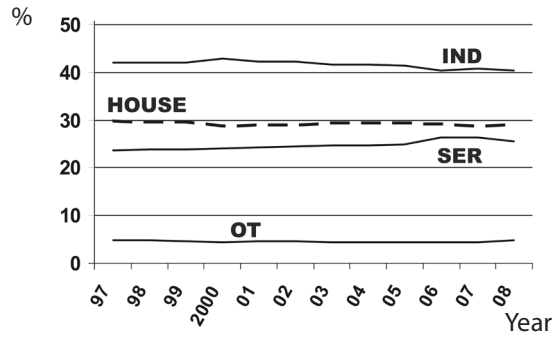

Fig. 35. Structure of final electricity consumption in TEC- %. Source: calculated from [3]

The total end-use electricity consumption per inhabitants in TEC in the period 2003–2008 registered an increase from 3.400 to 3.924 kWh/cap; index 115 (2003=100). The largest consumption per capita (2008) was reported by Slovenia (6.370) and the Czech Republic (5.587), whereas the smallest was recorded in Romania (1.888 kWh/cap.); cf. Croatia = 3.632 kWh/cap. The growth of over 25% during this period was registered in Latvia (131%), Lithuania (130%), Estonia (127%) and Croatia (125%); see Fig. 36.

Developed European countries have larger electricity consumption per capita than transition countries: from 8.676 (2003) to 8.882 kWh/cap (2008). The largest consumption (2008) was recorded in Norway (23.531), Finland (15.586), and Sweden (14.010), and the smallest in Italy (5.180) and Denmark (6.095 kWh/cap); see Fig. 37.

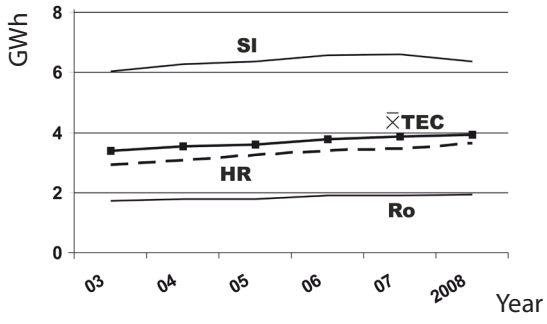

Fig. 36. Final electricity consumption per capita in TEC – GWh. Source [6]

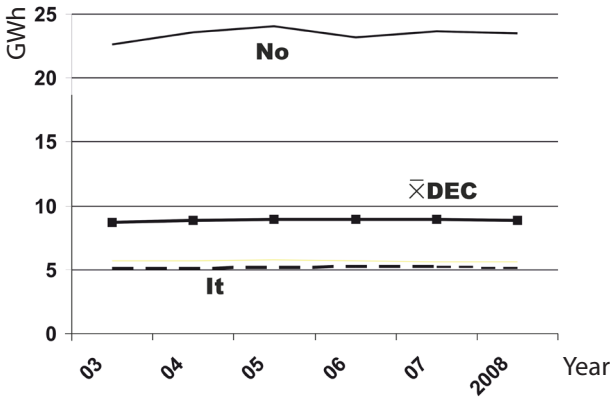

Fig. 37. Final electricity consumption per capita in DEC – GWh. Source [6]

Dynamics of average consumption growth per capita is shown in Figure 38; with base 2003 indices are TEC 115, Croatia 125 and DEC 102.

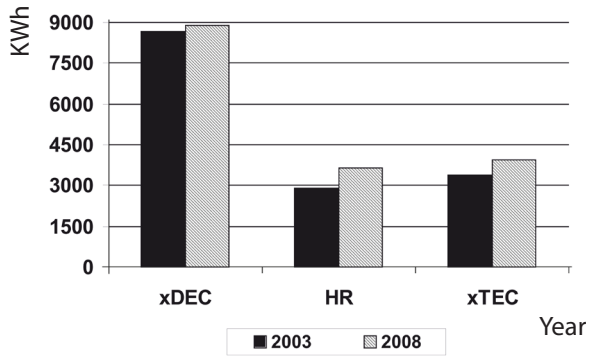

Fig. 38. Average of the final electricity consumption per capita in DEC, TEC and Croatia – kWh. Source calculated from [6]

2.6. ELECTRICITY DISTRIBUTION LOSSES

Electrical losses are an inevitable consequence of the transfer of energy across electricity distribution networks; they are undesirable and costly.

While there are many similarities in distribution networks operated by each distribution business, there are some important differences including a geographical size of the area where the network is located, the number of customers connected to the network, quantity of electricity distributed, a degree of dispersion of customers across the network, proportion of different types of customers connected to the network, and the amount of underground cables compared to overhead lines [12].

The recorded losses can be broken down into three main categories; variable losses, fixed losses and non-technical losses. Variable losses vary with the amount of electricity distributed and are, more precisely, proportional to the square of the current (utilization of capacity, higher voltages, shorter or more direct lines, demand management and balancing 3 phase loads). Fixed losses do not vary with current. These losses take the form of heat and noise and occur as long as a transformer is energized. Between 1/4 and 1/3 of technical losses on distribution networks are fixed (quality of transformer core material, elimination of transformation levels, switching off transformers). Non-technical losses comprise units delivered and consumed, but not recorded as sales (meter errors, measurement errors in the settlement system, unmetered supply and illegal abstraction of electricity). Other sources of non-technical losses include illegal abstraction of electricity. This mainly consists of tampering with meters and illegal connections. It is not currently possible to gauge the exact extent of illegal abstraction, as a proportion of this is likely to be undetected [13]-[17].

Electricity distribution losses in TEC decreased from 48.1 TWh (1997) to 39.6 TWh (2008) or from 16.1% of the final consumption (1997) to 11.1% (2008). The largest losses of the final consumption were recorded in Romania 17.2% (1997 and 2008), Bulgaria 22.6% (1997) to 16.3% (2008) and Estonia (29.3-16.2%). The smallest distribution losses were realized in Slovakia 9.1 to 4.2% (2008), Slovenia (7.0-6.3%) and the Czech Republic (10.3-8.0%); cf. Croatia (16.3-10.6% (2008)); see Fig. 39.

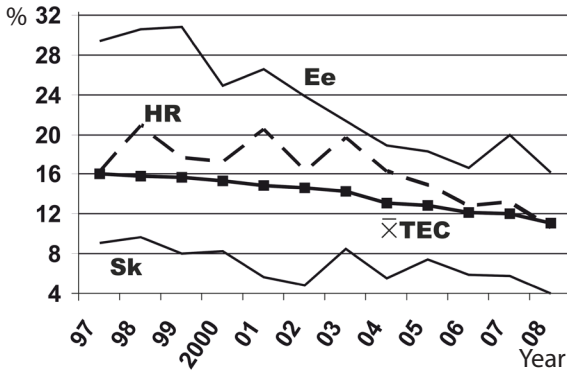

Fig. 39. Distribution losses in the final electricity consumption in TEC - %. Source [3]

Electricity distribution losses in DEC are smaller than those in TEC. There is a smaller average of losses in the same period and they vary from 7.0% (1997) to 7.3% (2005), and decrease to 6.7% in 2008. The largest losses were recorded in Norway - from 8.02% (1997) to 9.2 (2008), Sweden - from 8.2% to 8.5% (2008), Ireland – from 9.9% to 8.4% and Great Britain – from 8.7 to 8.3 (2008). The smallest distribution losses were realized in Finland – from 3.6% (1997) to 4.0% (2008), the Netherlands – from 4.2% to 4.3% and Belgium – 5.2% in 1997 and 2008; see Fig 40.

A direct comparison of distribution losses between TEC and DEC is shown in Figure 41. In both groups of countries distribution electricity losses decreased; in TEC this fall is significantly larger and measured with index (1997 = 100) it amounts to 69.1, whereas in DEC= 96.1; cf. Croatia = 65.0.

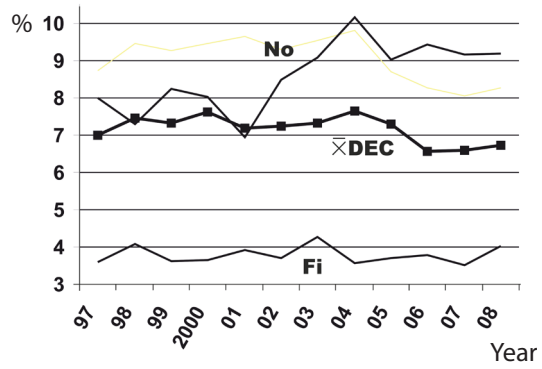

Fig. 40. Distribution losses in the final electricity consumption in DEC - %. Source: calculated from [3]

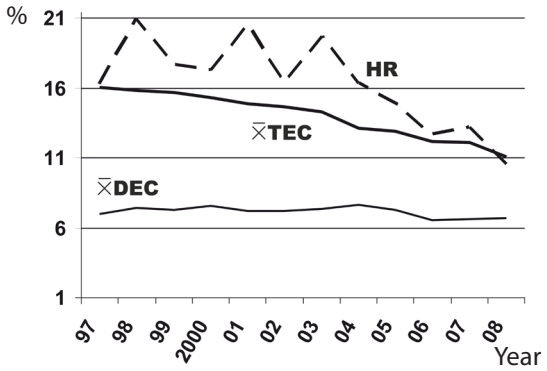

Fig. 41. Distribution losses in the final electricity consumption in TEC and DEC - %. Source: calculated from [3]

3. CONCLUSION

Based on the presented analysis one can draw a conclusion on several different levels. The first is a basic analytical frame shown in Table 4:

Table 4. Basic analytical frame

	Electricity consumption (physically) by					Distribution losses
	Industry	Services	Transport	Households	Per capita	
TEC	⇧	⇧	⇩	⇧	⇧	⇩
DEC	⇧	⇧	⇧	⇧	⇧	⇧
HR	⇧	⇧	⇧	⇧	⇧	⇩
	Electricity consumption (share in total) by					
TEC	⇩	⇧	⇩	⇩		⇩
DEC	⇩	⇧	⇩	⇩		⇩
HR	⇩	⇧	⇩	⇩		⇩

a) Electricity consumption increased, measured by electricity units, during the period 1994-2008 in transition European countries and Croatia by industry, service and households as well as the total of the final electricity consumption per capita. Consumption increased in developed European countries as a control group;

b) Consumption in transport decreased in TEC, and increased in Croatia and DEC;

c) Consumption in all sectors in TEC (and Croatia) has larger oscillations in comparison to consumption in DEC;

d) Consumption as a share of the total electricity end-use consumption in TEC, Croatia and DEC, dropped in the industry, households and transport sector, but increased in the service sector;

e) Distributions losses in TEC (and Croatia) are greater than in DEC by 230% (1994) and 165% /2008);

f) Distributions losses - as a share of the total electricity (end-use) consumption dropped in TEC (and Croatia) and DEC.

These processes are a result of different causes and will have an economic, environmental and technical effect.

Technical (electricity) context

a) Variations in consumption cause disabilities in the management of electricity system, enlarge the possibility of malfunctions, make maintenance planning difficult and reduce the efficiency of the electricity system. On the other hand, stable consumption in DEC alleviates management of the system, reduces the possibility of malfunctions, mitigates planning of plant exploitation and increases the efficiency of the electricity system.

b) A change in the economic structure strongly influenced the structure and regime of electricity consumption. TEC records larger consumption and a larger increase in the services sector (small-scale industry), i.e. power supply from low-voltage carrying larger distribution losses. DEC have a greater percentage of large industrial consumers, i.e. supply on the threshold of a high voltage and smaller distribution losses.

c) Large distribution losses in TEC, on the other hand, are a result of an undeveloped structure of the electricity system and insufficient investments into the quality of a distribution network.

d) Emerging technologies in the industry, services and households in electricity consumption have large positive effects on all sectors of consumption; in DEC these positive effects are larger than in TEC.

Economical context

a) The industrial sector experienced significant changes through restructuring industrial productions abandoning labour-intensive and electricity intense industries in both groups of countries. These processes operate on the structure and the mode of the electricity system in TEC and DEC groups of countries.

b) Large distribution losses in TEC, in one part, are and result in no technical causes, i.e. illegal consumption; it is an economic and administrative problem.

c) Significantly larger distribution losses in TEC affect (through price) all consumers such that competitiveness of the economic sector decreases while costs in the public sector and households referring to consumption unnecessarily increase.

d) Economically unjustified high electricity consumption in TEC households is questionable, esecially heating systems based on electricity, storage water heater and use of electricity for cooking. For these TEC need special projects on gas and renewable energy uses [18]-[21].

Environmental context

a) Irrational and unnecessary consumption of electrical power in each European country, especially in TEC, has its specific resultants in environmental protection.

b) Using electricity for processing sanitary-water heating and heating in the sector of household and services reduces the efficiency of uses of primary forms of energy (fossil fuels) and contributes to larger air pollutions and a larger greenhouse effect.

Policy context

a) Numerous EU action plans in the area of energy supply have already made good effects in DEC and TEC with respect to profiling energy policies. If there had been no EU directives, the situation in the electric power sector (and other energy sectors) would be more unfavourable than it is today [22]-[23].

b) In addition to EU directives, TEC (and Croatia) must have special projects aimed at increasing the efficiency of electricity use in order to fit into the EU framework of electric-power efficiency much faster and more easily.

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