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HEAT STORAGE FOR RESIDENTIAL SECTOR APPLIANCE

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INTRODUCTION

The residential sector is the second biggest in electricity consumption, right after industry. Households use energy for various purposes: space and water heating, space cooling, cooking, lighting and electrical appliances and other end-uses (mainly covering uses of energy by households outside the dwellings themselves). Data on the energy consumption of households broken down by end-use, have been collected and published by Eurostat since 2017. In 2019, households, or the residential sector, represented 26.3 % of final energy consumption or 16.9 % of gross inland energy consumption in the EU [2]. During the 10-year period from 2009 to 2019, the consumption of electricity by households in the EU rise by 0.8 %. These figures on overall household electricity consumption are likely to be influenced, in part, by the average number of persons living in each household and by the total number of households, both of which are linked to demographic events. The efficient use of energy by domestic appliances, along with the possibility of recovering and reusing their waste heat, is becoming more and more relevant.

Energy consumption in households in Europe and in Serbia

Energy use in the household sector differs widely between countries because of weather conditions, the state and age of the building stock and household appliances, the average size of the dwellings, the heating/cooling systems used, behaviour (particularly with respect to cooking) and the level of implementation of energy efficiency measures. In 2016, per capita energy consumption in the household sector of the EU countries ranged from 0.2 tons of oil equivalent per capita (toe/capita) in Malta to 1 toe/capita in Finland. [2, 8-11]

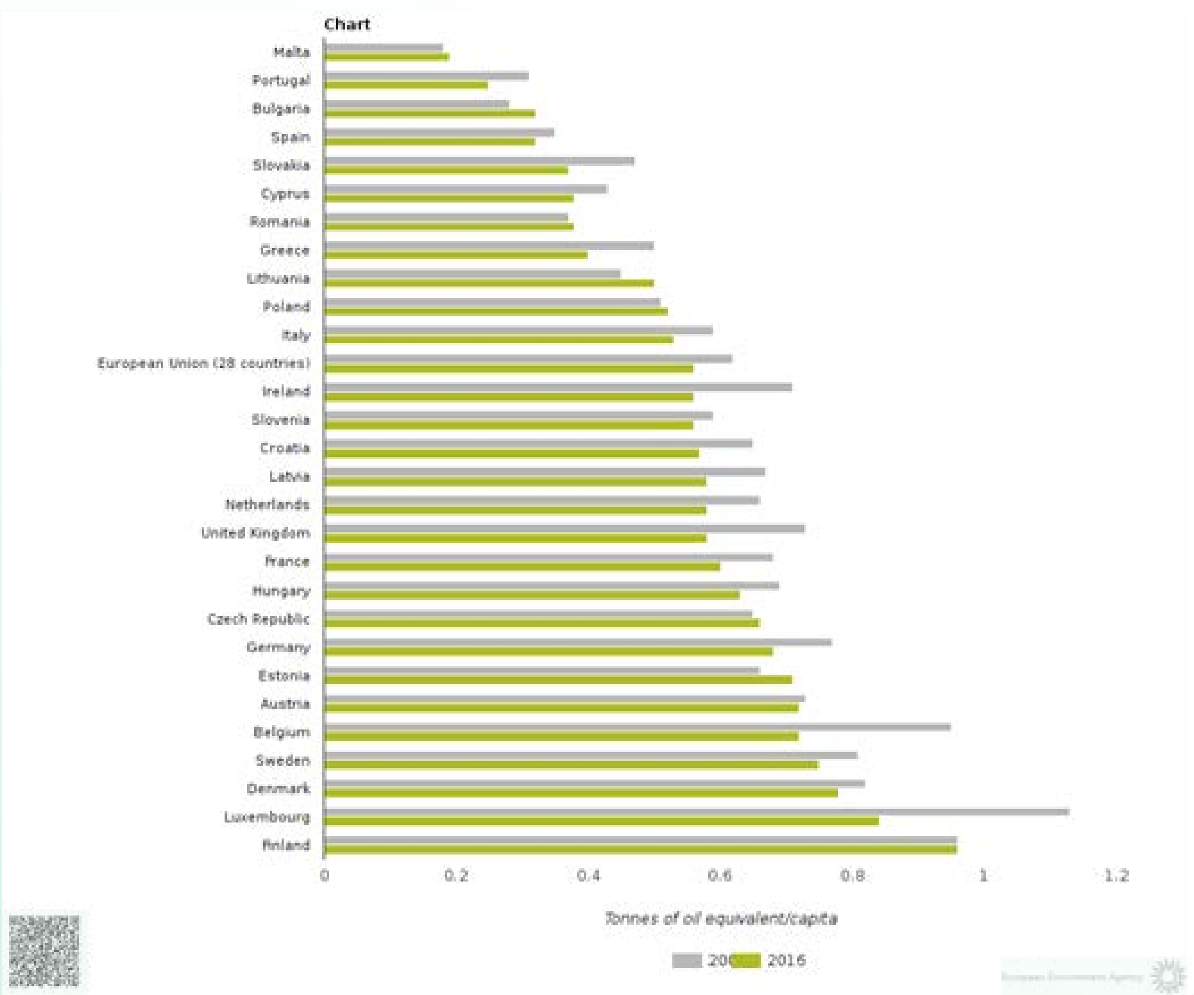


Fig. 1. Per capita final energy consumption of the households sector, by country [16]

Biggest consumer in Europe, from all 27 countries is Finland and right next to Finland are Luxembourg, Denmark, Sweden, and explanation we can find in climate and temperature in the winter time in those countries. Finland in 2020, consumed the amount of electricity of 67,46 TWh, and just for comparation Serbia consumed 35.52 TWh in 2020.

Housing industry's share in energy consumption amounts to 48% of total consumption, 65% of which refers to energy consumption in residential buildings ranging from 150 to 250 kWh/m^2 on average [3].

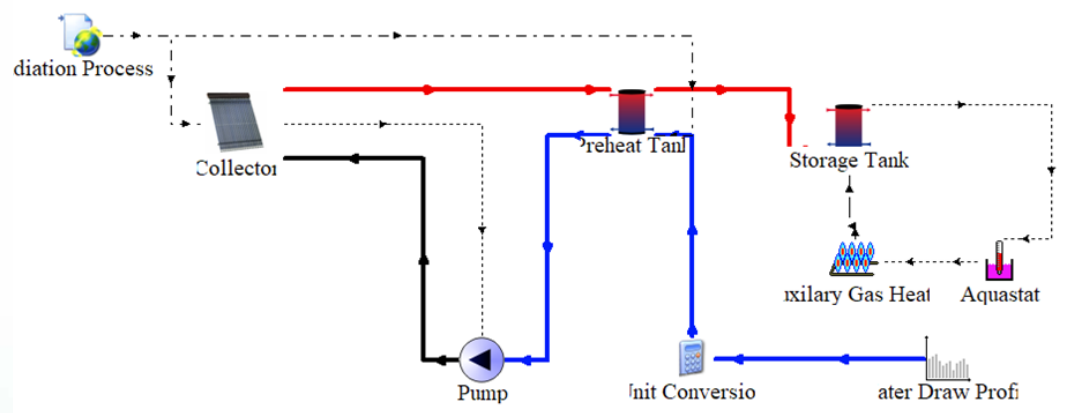
Common appliances in households and their consumption

According to literature the number of domestic appliances in the European Union is continuously growing and the same goes for how often that appliance is in use, as well as for the duration of their duty cycles. According to model, given in the literature, parameters of active and stand-by consumption of an appliance are linked to the annual consumption model according to the following equation [3,6]:

$$E_{yearly} = \left(3600 \times 24 \frac{s}{day} \dot{E}_{stand-by} + f \sum_{n=1}^{n_{cycle}} \dot{E}_{cycle,n} t_{cycle}\right) \frac{365}{3{,}6 \times 10^6} \frac{daykWh}{Ws}$$

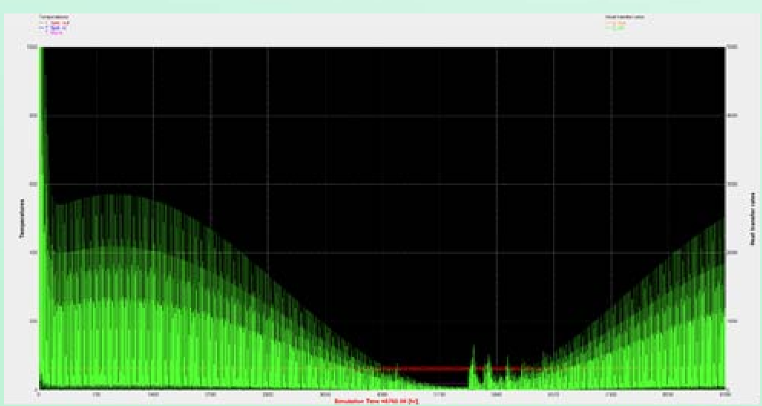
What should we take into account when we try to optimal capacity

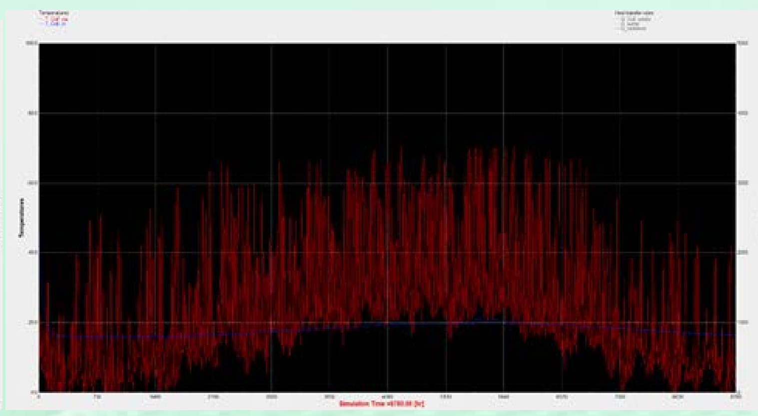
Schematic representation of the considered system



RESULTS AND DISCUSSION

The results obtained by simulation are presented. Simulation is given for the whole year, 8760h. The heat exchanger fluid is water with: density 1000[kg/m^3], thermal conductivity 2.14 [kJ/hmK], specific heat 4.19 [kJ/kg K]. Tank properties are: number of tank nodes is 8, tank volume is 1[m^3], top and bottom loss coefficient is 5[kJ/hm^{2}K], and initial tank node temperature is 55[ºC]. Solar collector has a array area of 2[m^2], number of nodes is 10, flow rate per unit area is 50[kg/hm^2]. Aquastat is set so that fluid inlet temp. is 20[ºC], and setpoint temperature for stage is 50[ºC]. Hysteresis +/- 2 [ºC]. Preheater has heating capacity of 16200[kJ/h]. The results in the paper are presented for a typical meteorological year, for the solar radiation data for Nis, Serbia, with 1h timestep resolution.





CONCLUSION

In this paper, a review of the status of energy consumption in EU households is presented and analysed. It is concluded that sanitary hot water accounts for almost 20% of the household electricity consumption. The simulation indicated that the design of the system and choice of hot water tank desired temperature level, as well as dynamics of the consumption and availability of the solar energy can strongly affect the effectiveness of the solar system. As the simulation results show, if the hot water tank temperature is set to high, solar collectors may provide insufficient heat flux for most of the year, except for the summer period. The solar systems are sized this way, i.e. based on the minimum heat demand in the hottest summer periods, to avoid the so called solar thermal system stagnation, which can lead to system damage. Therefore, for the high desired tank temperatures, the auxiliary heater is responsible for meeting most of the hot water energy demands. Different scenario can be expected in the case of lower desired tank temperatures, but this can be analyzed in some future research, and is omitted from this study.

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