# THE APPLICATION OF RES AND INFLUENCE ON BUILDINGS ENERGY NEEDS AND ENERGY CONSUMPTION

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# INTRODUCTION

- Energy consumption in buildings in Serbia has been growing steadily
- The Total Final Energy Consumption reached 8.5 Mtoe.
- Energy consumption in buildings is 38 % while in industry and traffic is 34 % and 28 % respectively.
- In this context, the buildings sector provides significant opportunities for energy savings.
- Heating accounts for 61% of energy consumption in buildings (the biggest potential for savings).
- A systematic campaign to approach solving the problem of uncontrolled, disorganized, irrational and unsustainable use of energy and fuels in all sectors .

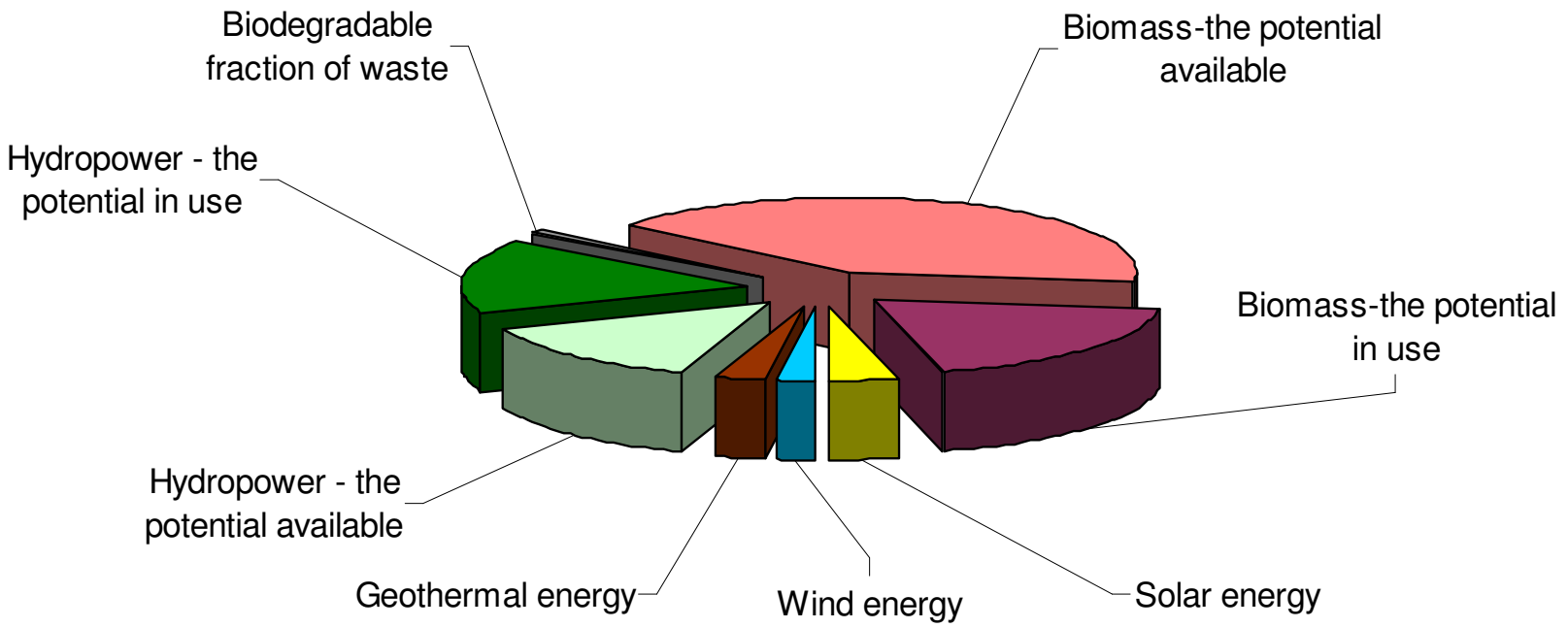
# INTRODUCTION

- Adopted are numerous documents, which provide a route to organized and sustainable treatment of energy issues.
- According to Article 20 of the Treaty establishing the Energy Community, the Republic of Serbia has accepted the obligation to implement **European Directives** in the field of use of RES.
- In accordance with **Directive 2009/28/EC** binding targets for Member States of the European Union are set to ensure that the RES, in 2020, accounted for 20% of the GFEC at the level of the European Union .
- In accordance with Directive 2009/28/EC and the Decision of the Ministerial Council of the Energy Community of October 18, 2012 determined is an ambitious binding target for the Republic of Serbia, which is 27% renewable energy in its GFEC in 2020.

# RENEWABLE ENERGY SOURCES

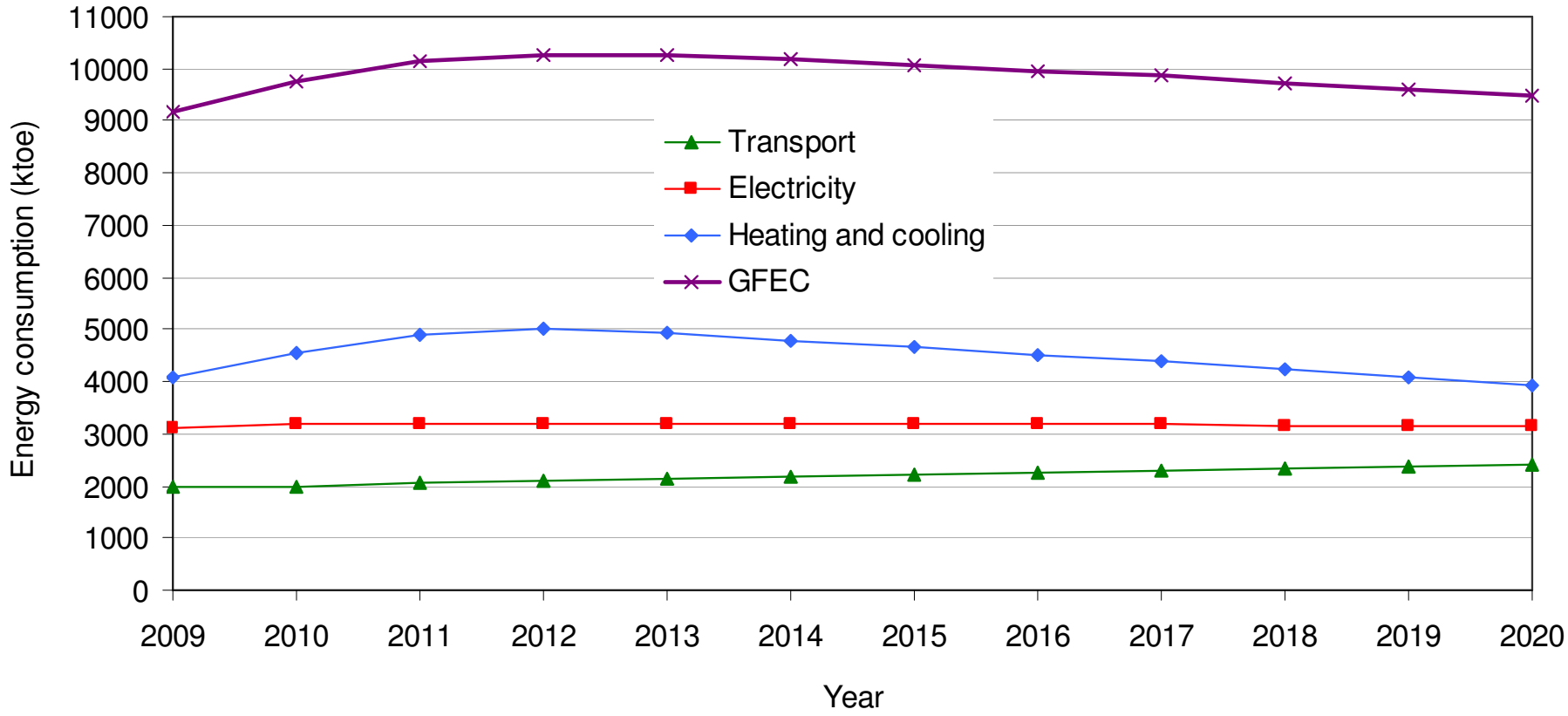
- Renewable energy sources, with an estimated technically exploitable potential of about 5.6 Mtoe per year can significantly contribute to the reduced use of fossil fuels and to the improved environmental conditions.
- Of the total of available technical potential of RES Republic of Serbia is already using 35% (0.9 Mtoe of used hydro potential and 1.06 Mtoe of the potential biomass and geothermal energy).
- The use of RES in the previous period was based on the production of electricity from large river flows, and the use of biomass, mainly for heating purposes in households, to a lesser extent in the industry.
- According to the data from the energy balance of the Republic of Serbia for 2009, the share of electricity from hydropower in GFEC amounted to 9.6%, while the share of thermal energy from biomass in GFEC amounted to 11.5%.

# RENEWABLE ENERGY SOURCES




**RES structure in the Republic of Serbia**

# NATIONAL ACTION PLAN FOR RES




**GFEC in total and by sectors –**

**according to the scenario with measures for energy efficiency**

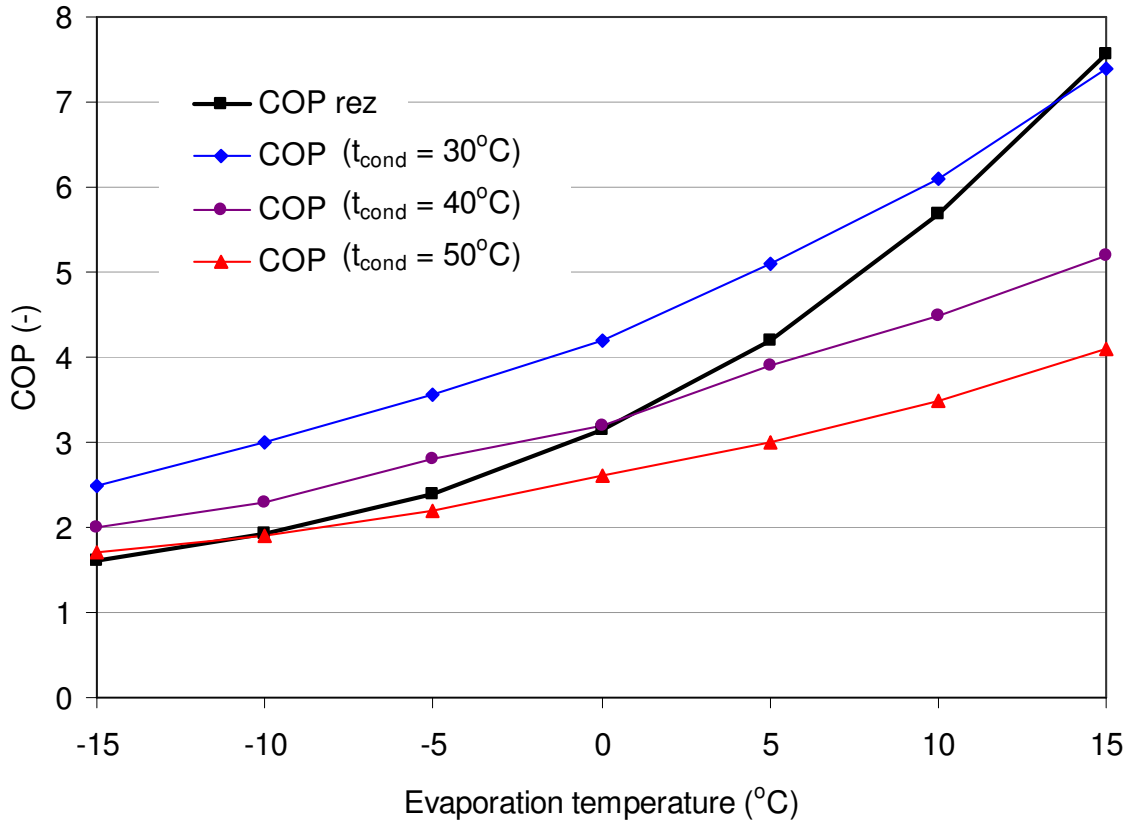
# AIR TO WATER HEAT PUMP APPLICATION

- According to the Directive 2009/28/EC, energy from renewable sources' means energy from renewable non-fossil sources, namely:
  - wind,
  - solar,
  - ***aerothermal***,
  - geothermal,
  - hydrothermal and ocean energy,
  - hydropower,
  - biomass, landfill gas, sewage treatment plant gas and biogases.
- Although the outdoor air is not considered as RES potential in the National Action Plan for RES, it shouldn't be ignored when it comes to single family houses. To this end, this paper analyzes the potential of outdoor air as a heat source for heating, for the Serbian climate conditions.

# AIR TO WATER HEAT PUMP APPLICATION

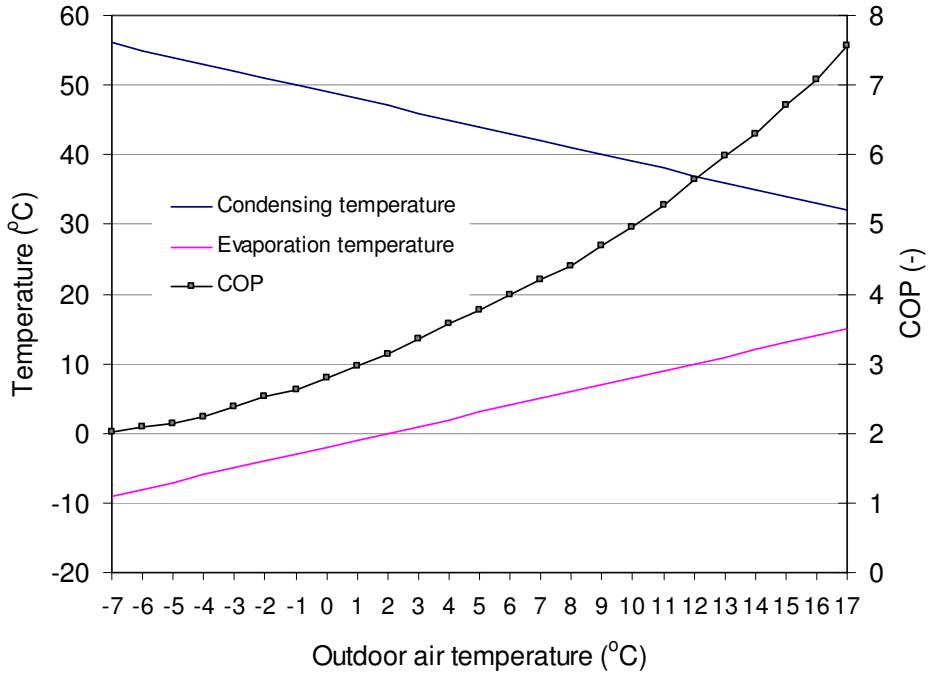
- With the outdoor air temperature decrease, it is necessary to increase supply hot water temperature in heating system, in order to cover heat losses of the building and maintain thermal comfort.
- On the other hand, this affects lowering of evaporation temperature and increase of condensing temperature of the refrigerant in the heat pump.
- Since the Coefficient of Performance (hereinafter COP) varies depending on the evaporation and condensing temperature relation, and the efficiency of utilization of outdoor air in the winter months is variable.
- Refrigerants that are in common use in air to water heat pumps of new generation is R 407c and R 410a, regarding improved environmental features.

# AIR TO WATER HEAT PUMP APPLICATION

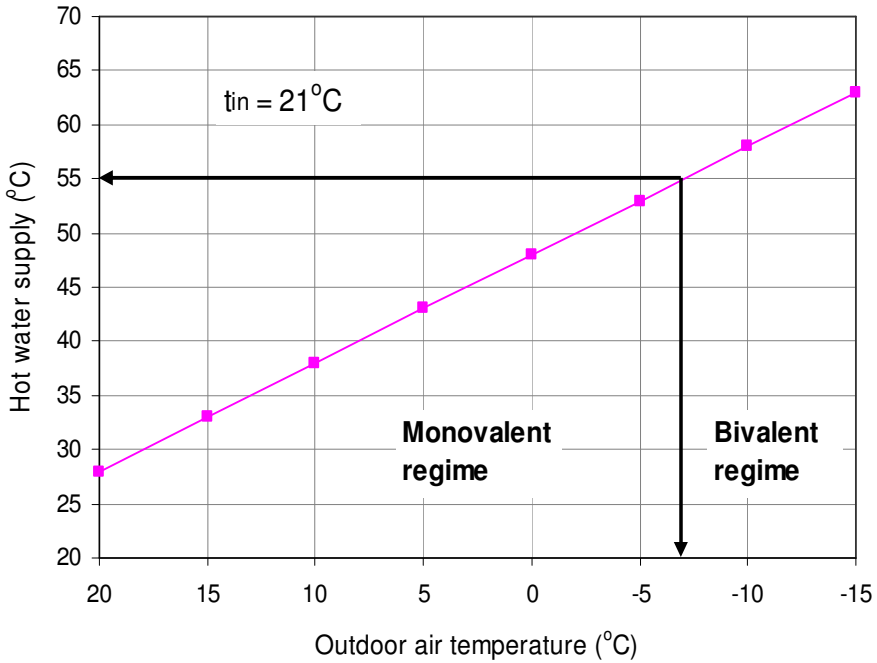



**COP variation depending on the condensing and the evaporation temperature for refrigerant R410A**

# AIR TO WATER HEAT PUMP APPLICATION

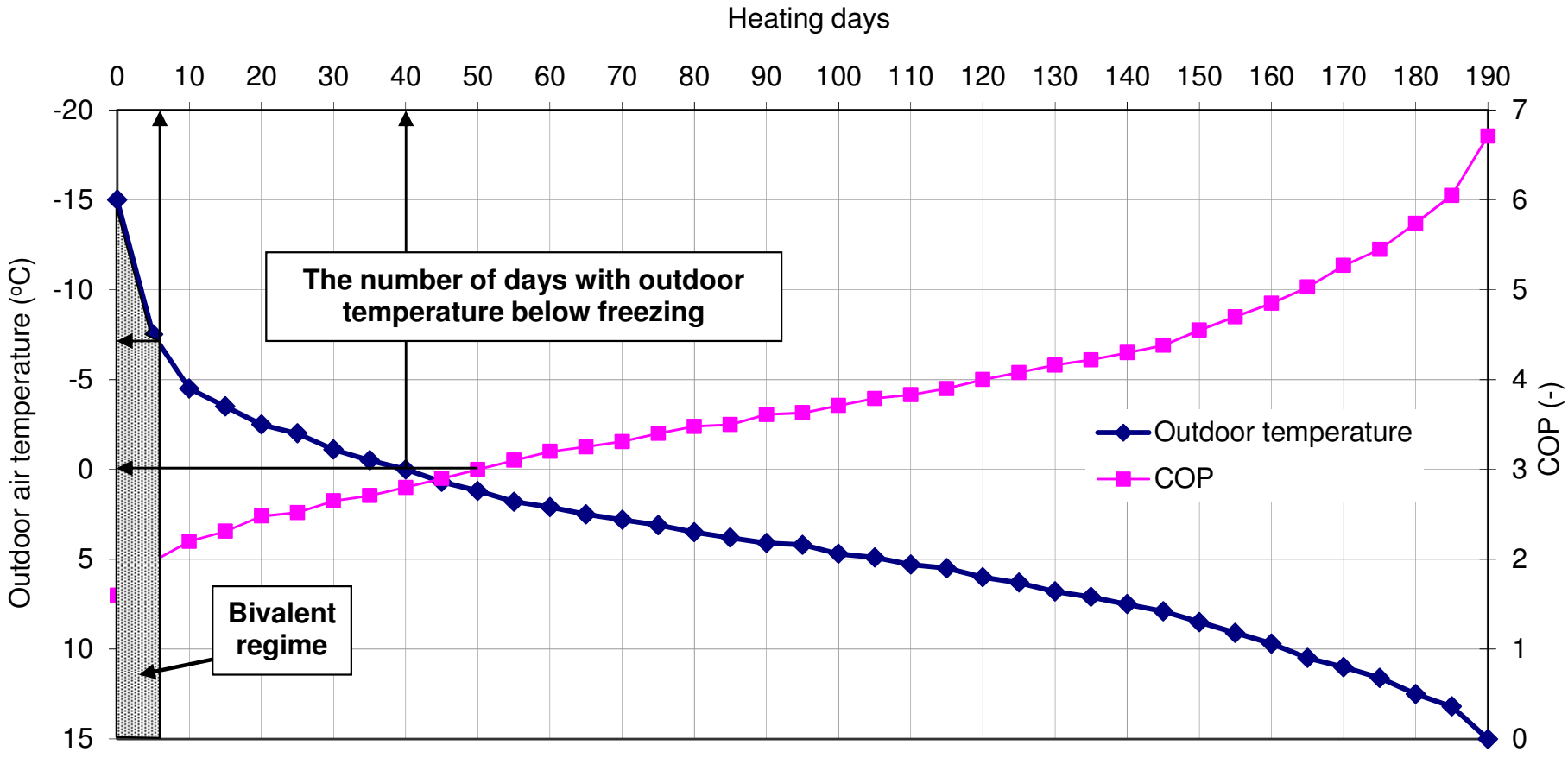



**Theoretical operating regime of heat pump**



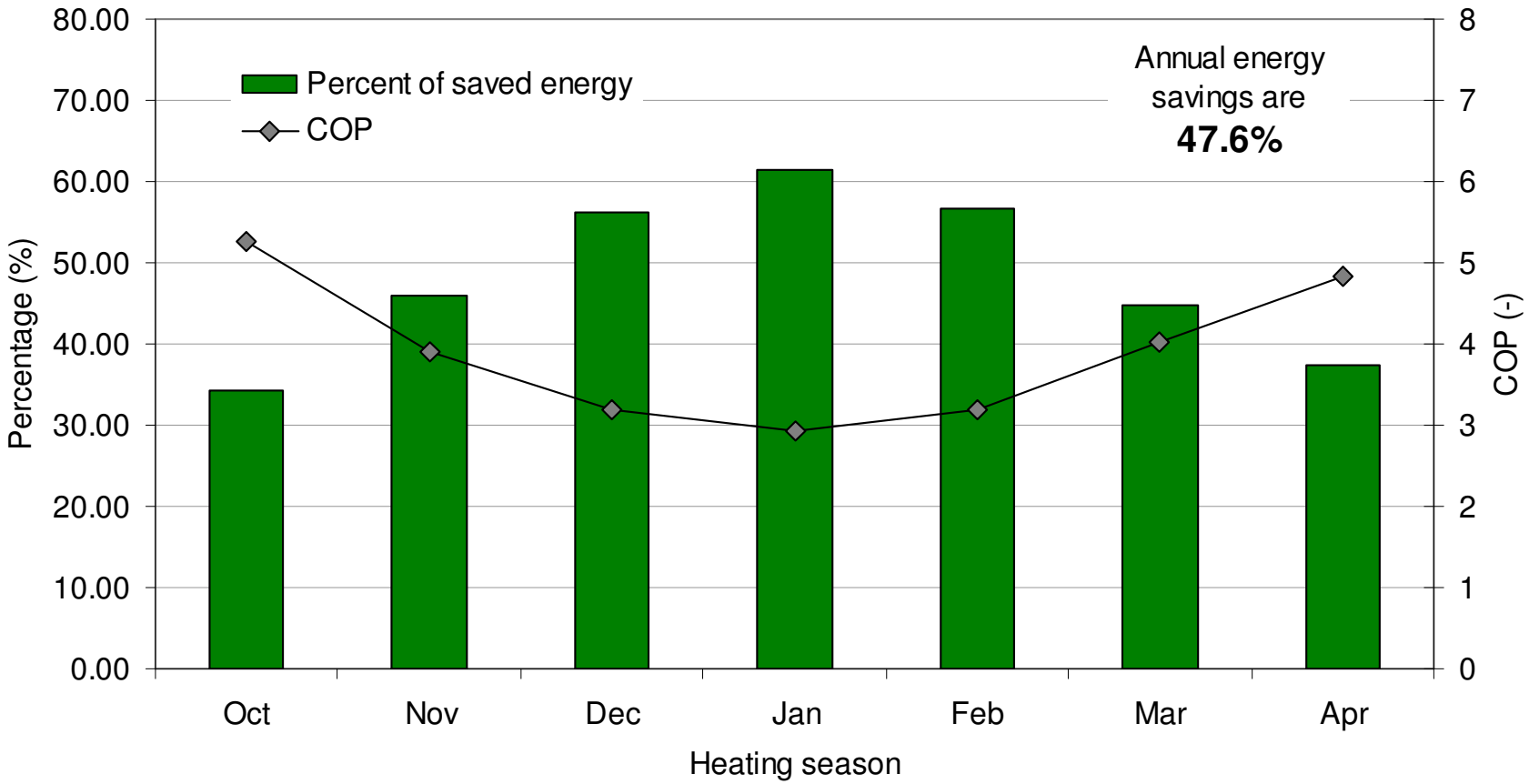

**Heating curve for low temperature radiator heating (63/48°C)**

# AIR TO WATER HEAT PUMP APPLICATION




**Seasonal heat load duration curve and COP change**

# AIR TO WATER HEAT PUMP APPLICATION

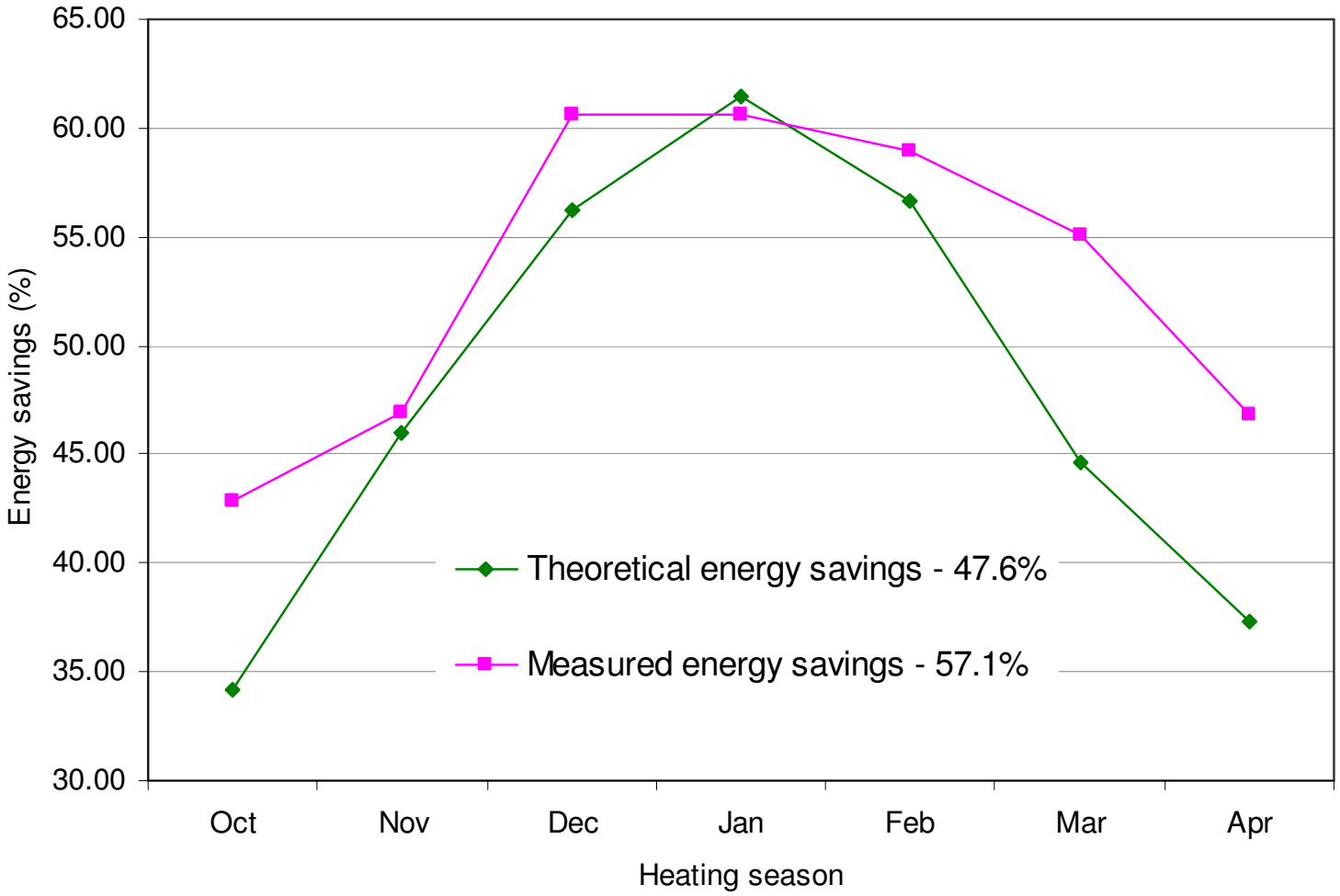



**Theoretical energy savings during the heating season**

# MEASUREMENT RESULTS

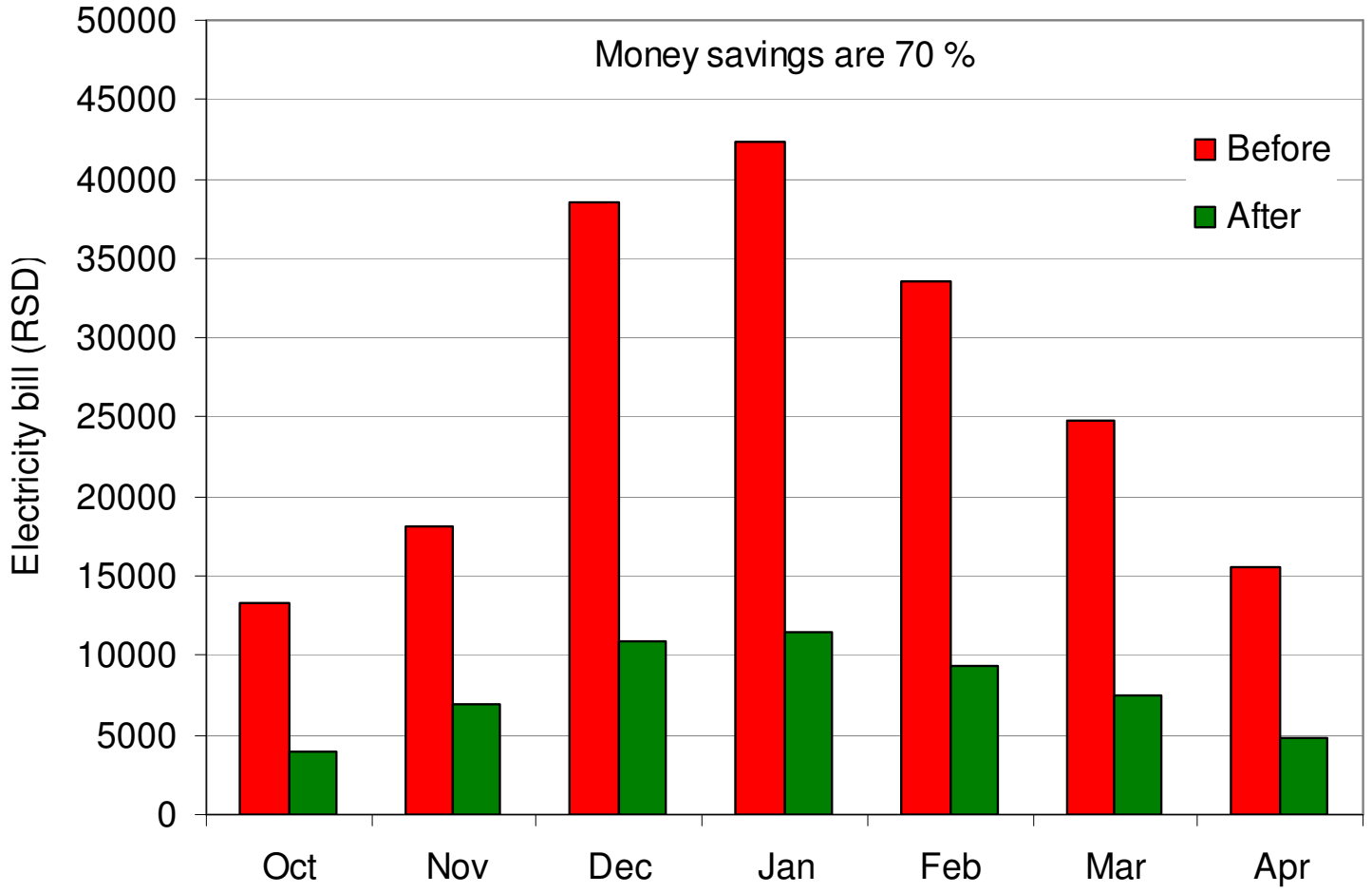
- In order to confirm the results of the theoretical analysis conducted in this paper, monitoring of the heat pump operation was carried out, after reconstruction of heating system in single family house in Belgrade.
- Net heating area is 120 $m^2$, with radiator central heating system in temperature regime of 63/48$^oC$.
- Final energy need for heating amounts to 80 $kWh/m^2$.
- Electric heating boiler (heating capacity of 18 kW) was replaced with the air to water heat pump of new generation (heating capacity of 8 kW with additional electrical heaters 2 x 3 kW).
- Monitored are: evaporation temperature, condensing temperature, external temperature, indoor temperature, heat pump operating hours, compressor operating hours in different stages, additional electric heater operating hours, etc.
- Measured is electricity consumption on monthly basis.

# MEASUREMENT RESULTS




**Comparison of theoretical and measured energy savings during the heating season**

# MEASUREMENT RESULTS




**Reduction of electricity bills during the heating season**

# CONCLUSION

- Analysis of application of air to water heat pump, conducted in this paper, has shown significant potential of external air use as a heat source.
- It is shown that heat pump can cover over 90% of heat demands. Calculation of the energy consumption for each day of the heating season is performed in order to determine electricity consumption.
- The results obtained through theoretical calculations and measurements are showing energy savings of approximately 50% on annual basis. A very imortant fact, in terms of heating system user, is decrease in monthly electricity bills. With regard to the tariff system of charging electricity, reduced consumption allows the user to avoid the consumption at the highest rate, which leads to money savings up to 70% per heating season.

# CONCLUSION

- The most important advantages of the air to water heat pumps application are the following:
  - the possibility of application when reconstructing the building envelope, without changing the heating system, but switching to low-temperature regime;
  - relatively low investment costs with payback period up to 6 years;
  - very low exploitation expenses for heating (from 2 to 3 euro per day);
  - improving thermal comfort by maintaining indoor temperature within the desired limits throughout the season;
  - engagement of the user is minimal considering fully automated operation;
  - the possibility of simultaneous application for heating and central preparation of domestic hot water.

# APPLICATION OF SOLAR SYSTEM AND GEOTHERMAL HEAT PUMP

Simulated building is located

in the center of Belgrade

- The total usable area is 1300 $m^2$
- The building is designed with good thermal insulation (0.37 [$W/m^2K$] for external walls), with average quality windows (1.8 [$W/m^2K$], a=0.4 [$m^3/mhPa^{2/3}$])
- There are 16 apartments (two of them are luxury penthouses), and 2 commercial properties on the ground floor

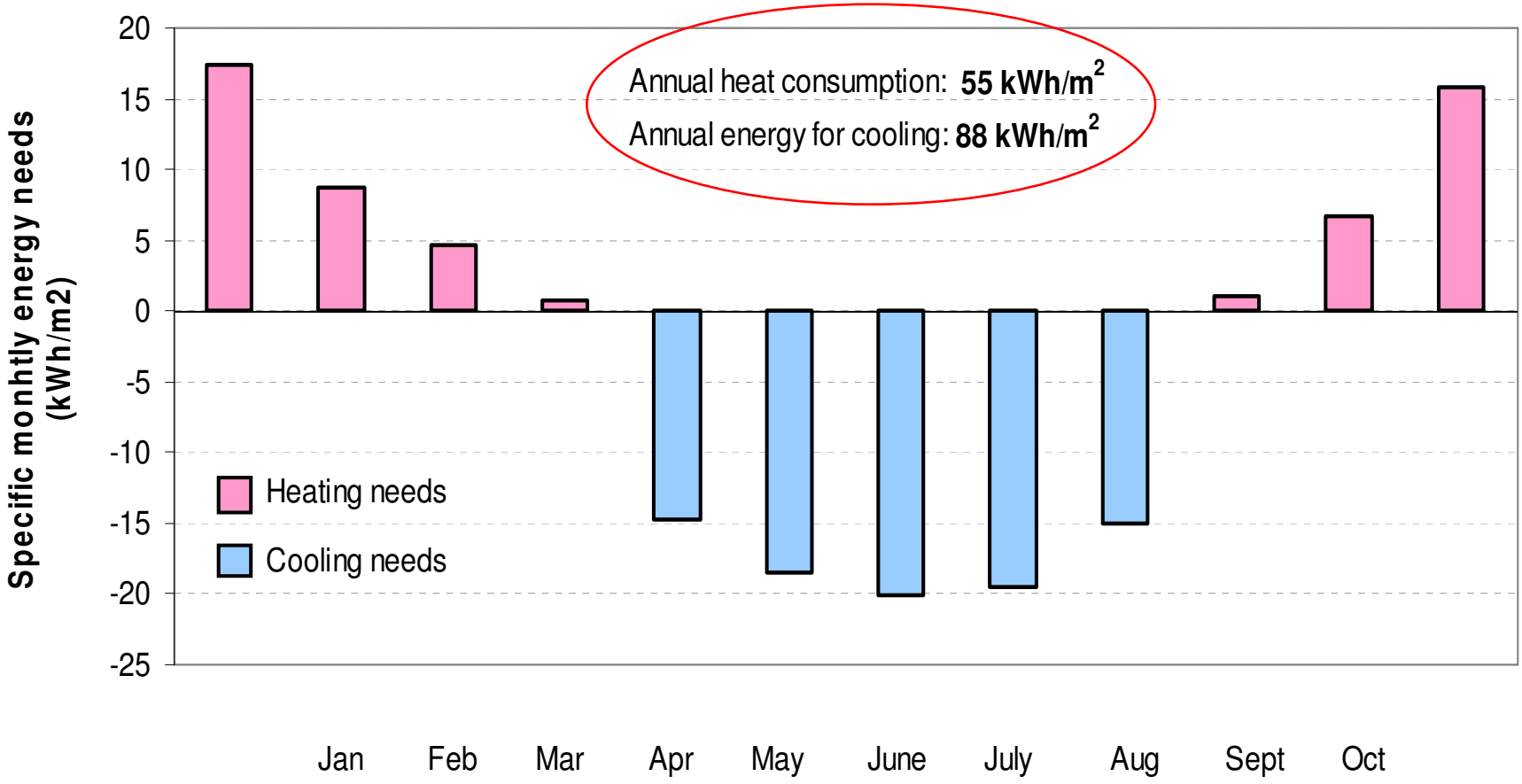
# THREE MODELS OF DIFFERENT TYPES OF ENERGY SOURCES FOR COMPARATION

- **Basic model (M0)** that is considering district heating system that generates heat from fossil fuels for heating, local air conditioning units (split systems) in every apartment and business property, and individual DHW preparation in each apartment and business property, using electrical boilers;

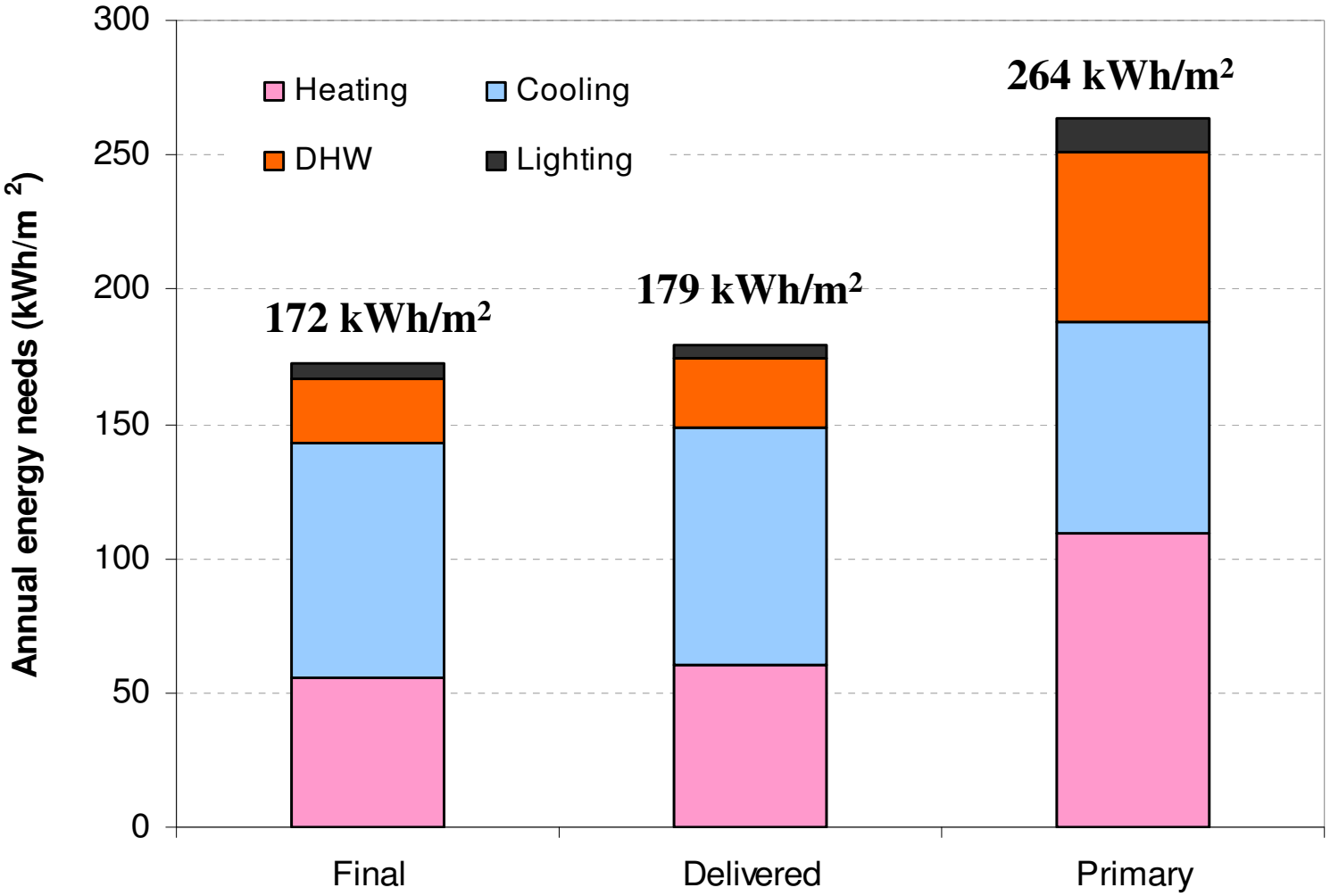
- **Model M1** is considering individual gas boiler for the heating for whole building, local air conditioning units (multi split systems) for each apartment and business property, and individual DHW preparation in each apartment and business property, using electrical boilers;

- **Model M2** is considering geothermal heat pump as a energy source for heating and cooling and solar heating systems for DHW preparation for whole building.

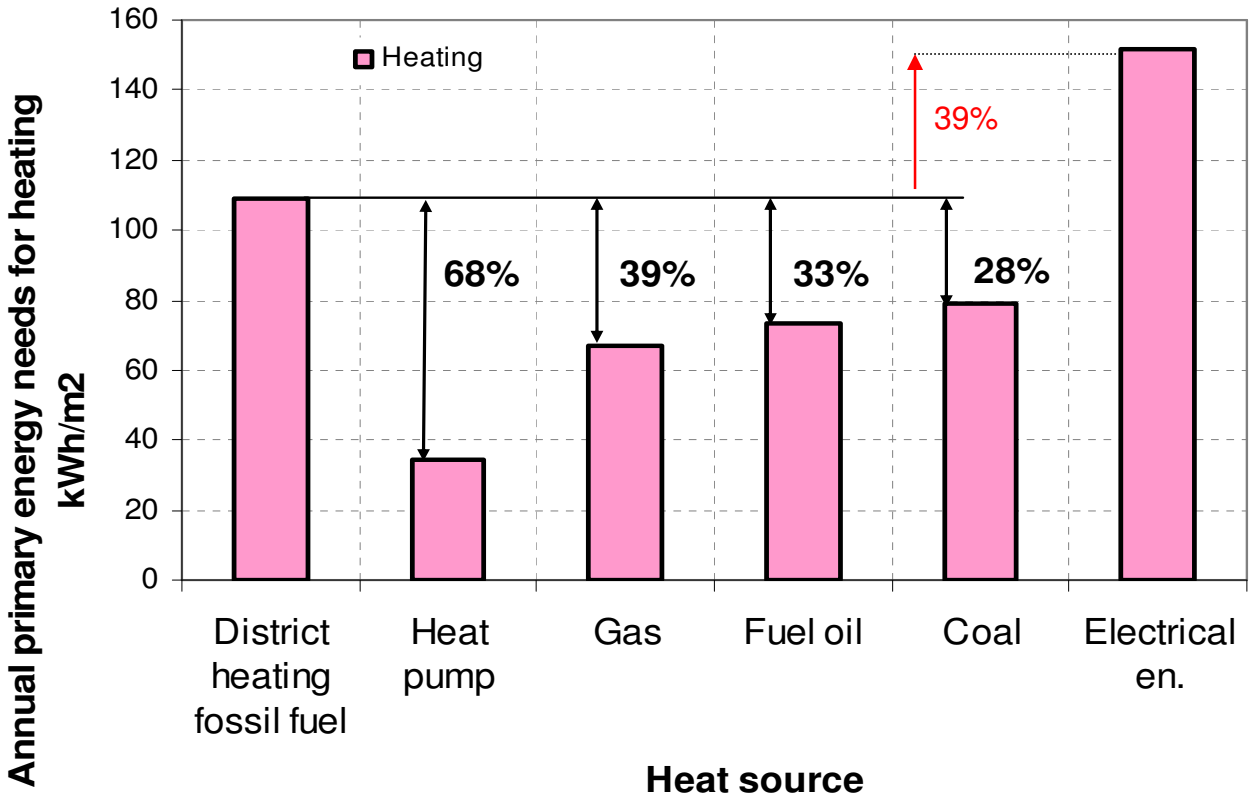
# MONTHLY ENERGY NEEDS FOR HEATING AND COOLING – BASIC MODEL



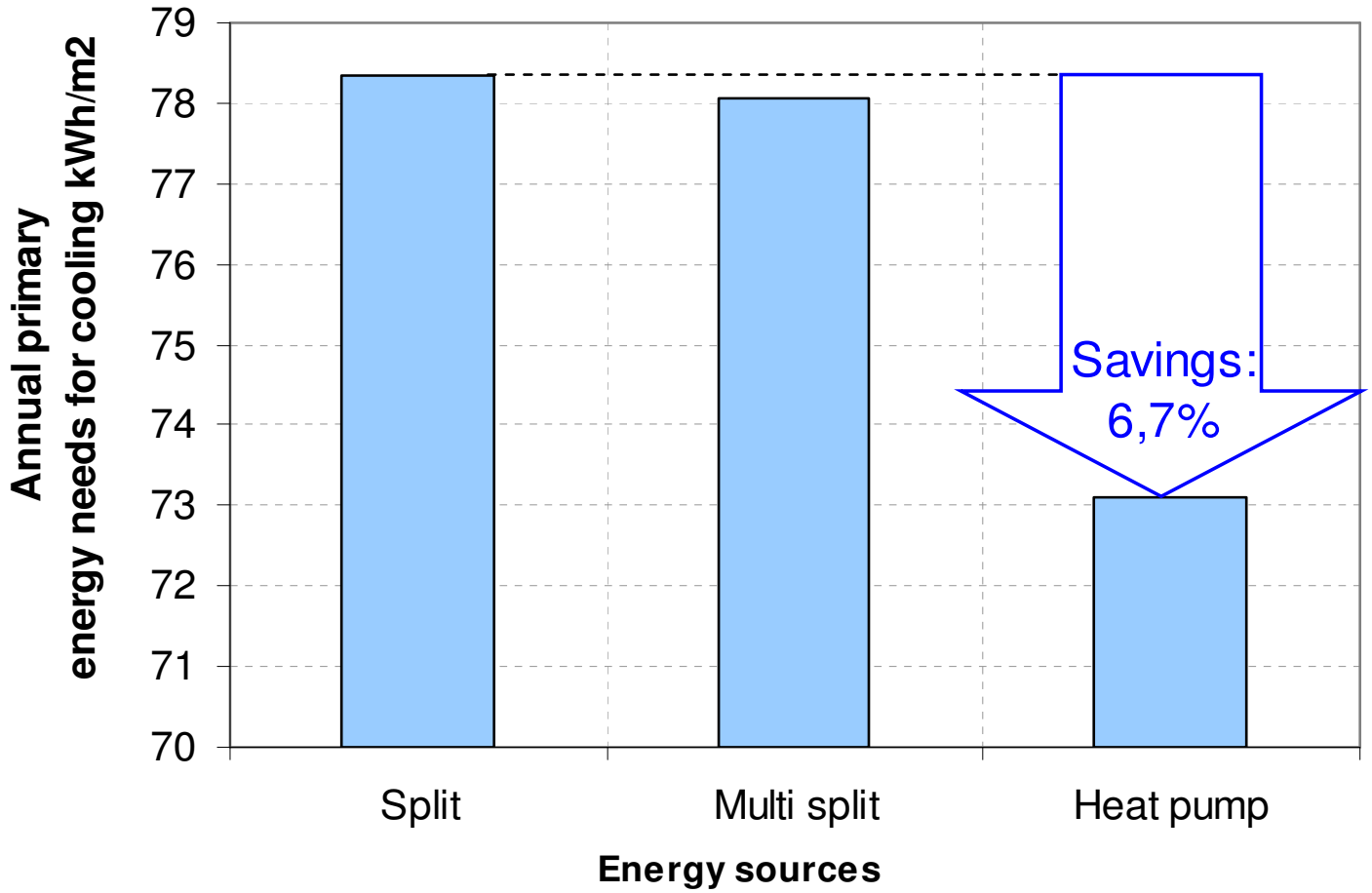
# ANNUAL ENERGY NEEDS – BASIC MODEL



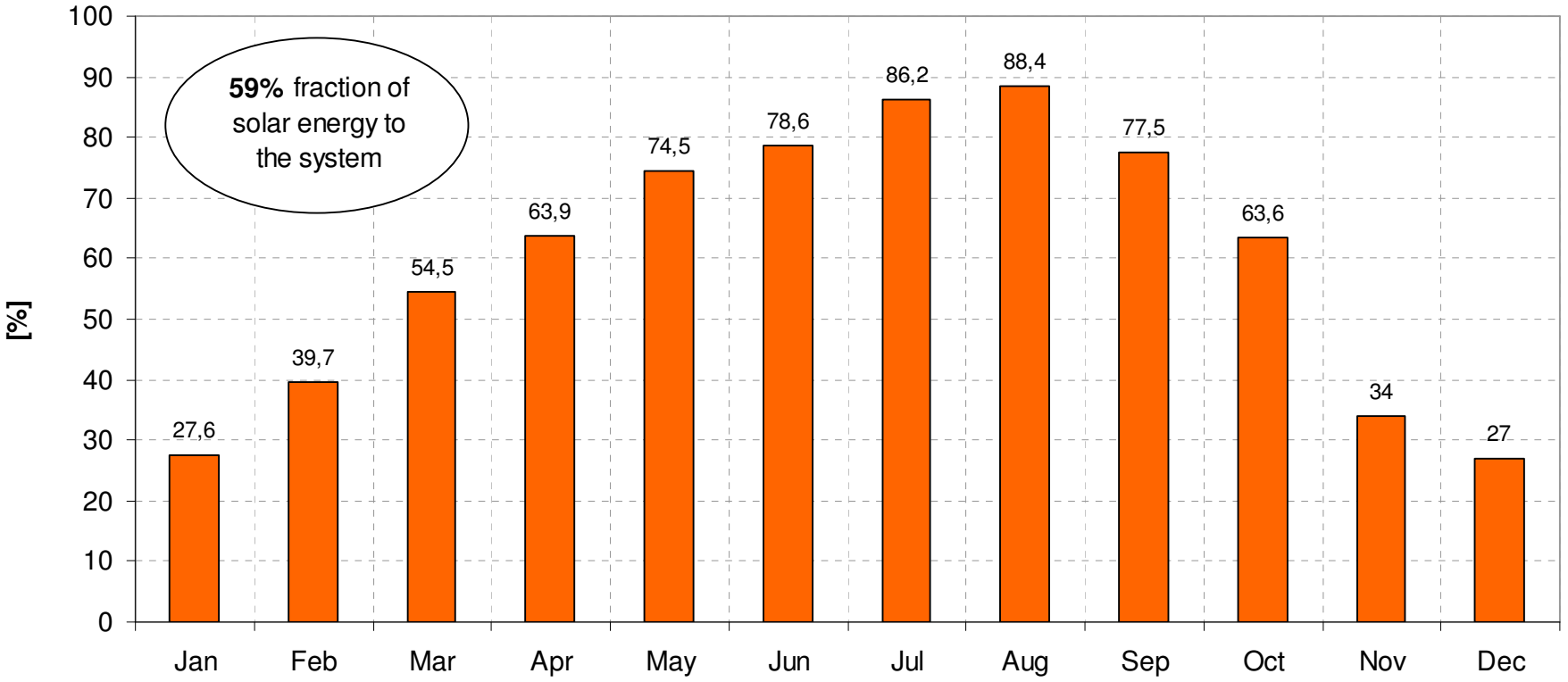
# HEATING PRIMARY ENERGY NEEDS DEPENDING ON THE ENERGY SOURCES TYPES



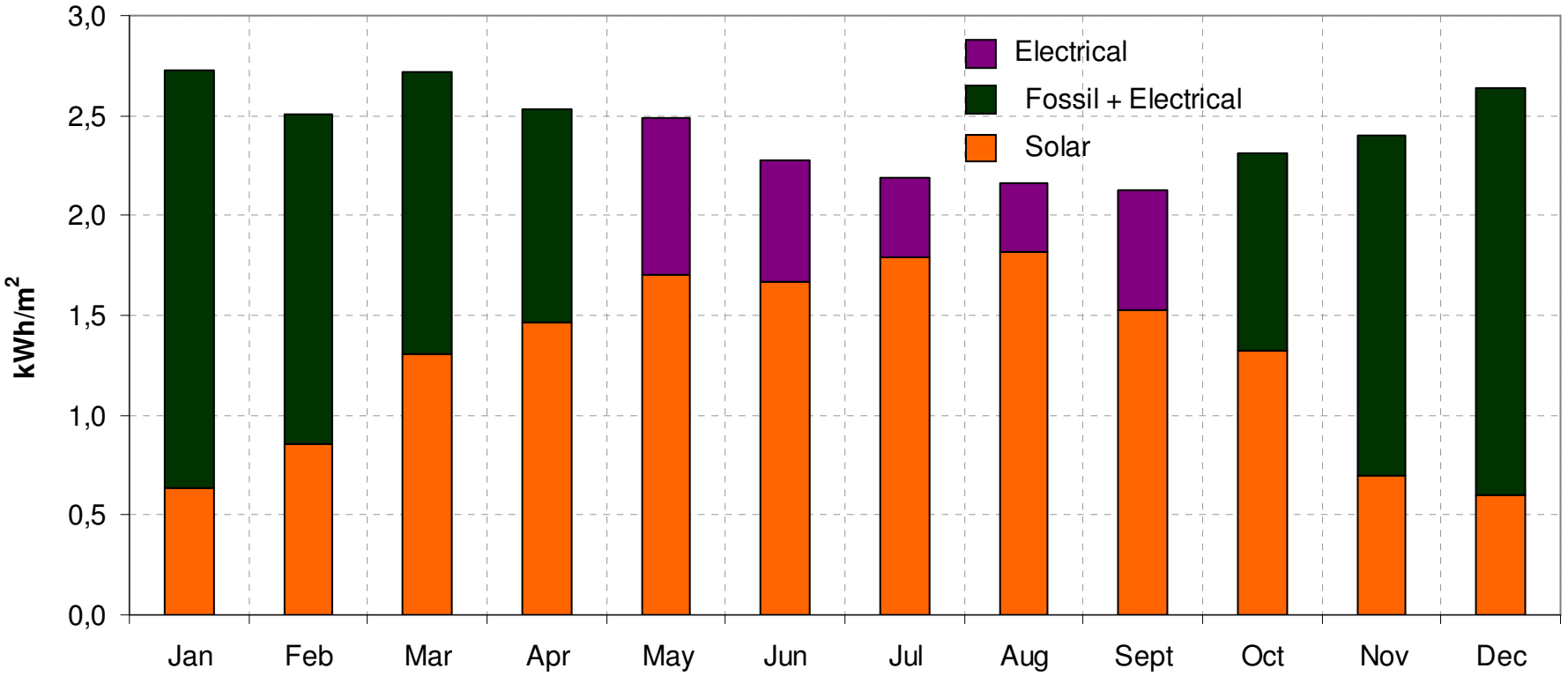
# COOLING PRIMARY ENERGY NEEDS DEPENDING ON THE ENERGY SOURCES TYPES



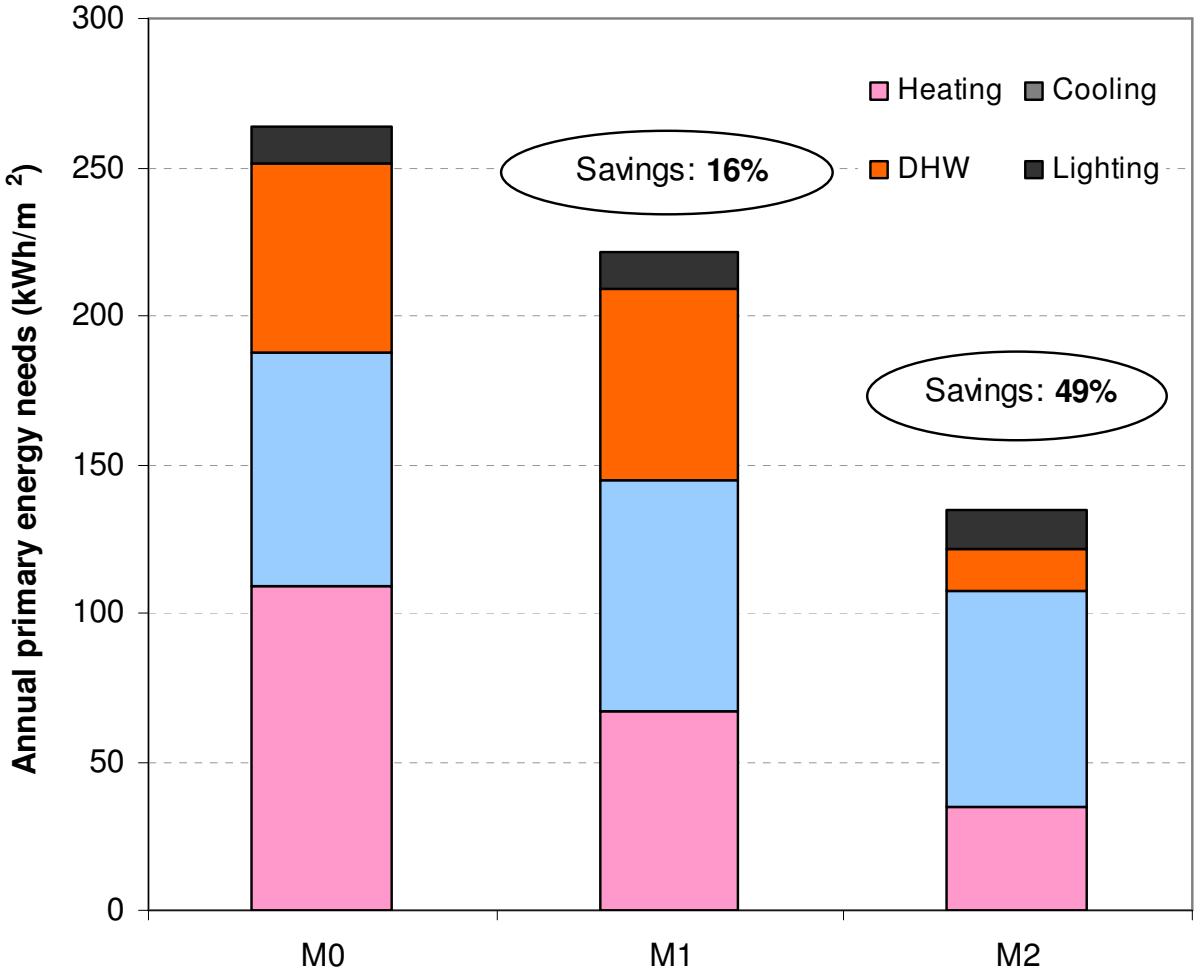
# FRACTION OF SOLAR ENERGY TO THE SYSTEM FOR DHW PREPARATION FOR THE BUILDING



# RATIO BETWEEN SOLAR AND FOSSIL AND ELECTRICAL ENERGY NEEDS FOR DHW PREPARATION



# OPTIMAL ENERGY SOLUTION AND ENERGY SAVINGS



# CONCLUSIONS

- The selection of energy source has a big impact on a primary energy needs.

- Primary energy savings that could be achieved by appropriate selection of a heat source type are going up to 68%, using heat pump as a heating source, comparing to the district heating system on a fossil fuel.

- With heat pump, approximately 7% energy savings could be achieved, comparing to the split system.

- With M2 energy solution, it is possible to achieve annual primary energy savings up to 49%.

# THANK YOU FOR ATTENTION!

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