# BASICS OF HEAT ENERGY DEMAND

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# CONTENT OF LECTURE

- Importance and EU legislation
- Energy labels of building
- Heat losses – U coeff.
- Energy demand for heating
- Technology examples

# Importance of energy efficiency of buildings

Buildings are currently responsible for app. 40% of energy consumption in EU and 36% of CO2 emissions

35% of buildings: older than 50 years

Reasonable improvement of energy efficiency of buildings can save 5-6% of energy consumed by EU and similarly contribute to CO2 redution

# Importance of energy efficiency of buildings 2

## INTRODUCTION

### Map


- Land area: 78867 km$^2$
- Population: 10,511 mil. (2013)
- Population density: 133/km$^2$
- GDP per capita: 388 771 CZK (nominal, 2013)
  (80% of EU28 GDP average, PP)
- Schengen area: yes

### Key figures

- Heat sales (M€)
  - aggregated data not available, only data for individual companies and data for heat production and delivery
- Final heat consumption (TWh)
  - 39.8 TWh (total)
  - 11.6 TWh (residential)
  - 28.2 TWh (production and services)
  - 15.2 TWh (delivery to final consumers from DH systems)
- Average DH price to final consumers (c/kWh)
  - 7,56 (2011)
  - 7,91 (2012)
  - 7,87 (2013)
  - 7,93 (2014, estimation)
- Inhabitants using DH (million)
  - 4 mil.
  - 1.55 mil flats (households)
- Market share of DH (%)
  - 38 %

# Key EU legislation 1

Directive 2010/31/EU on the energy performance of buildings

Directive 2012/27/EU on energy efficiency (2018 update – part of Clean energy for all europeans package

• CZ: obligation to renovate annually 3% of total floor area of public buildings (central institutions) with energy relevant area above 250 m2 – it includes 37 central institutions owning 775 buildings, required C classification is not fulfilling 586 buildings having 1.6 mil. m2 of floor area

• 2017 CZ reality: 16 buildings and 15 prisons (total savings 25 TJ only)

• required savings in 2020: 51 PJ! RES target is exceed, great problems with EE targets!

# Key EU legislation 2

Some measures:

- energy labels of buildings – to help customers decide, to create pressure for renovation
- inspection schemes for heating and air conditioning
- all new buildings must be nearly zero energy buildings by end of 2020
- New Green to Savings Project
- 2030 targets: reduction of energy consumption by 32.5% compared with the reference scenarion from 2007 (i.e. -0.8%/year from absolute final energy consumption)

# Key EU legislation 3

Within the framework of the winter energy package – Regulation on the Administration of the Energy Union

Regulation implies the obligation to elaborate the so-called National Climatic and Energy Plans

First National Plans should cover the period 2021-2030

National plans should include a contribution to meeting the climate-energy targets for 2030

Green Deal – new EU strategy for decarbonization until 2030

Shift from fossil fuels and coal

- Coal – biggest problem of heating branch in CZ
- Natural gas is just transient sollution

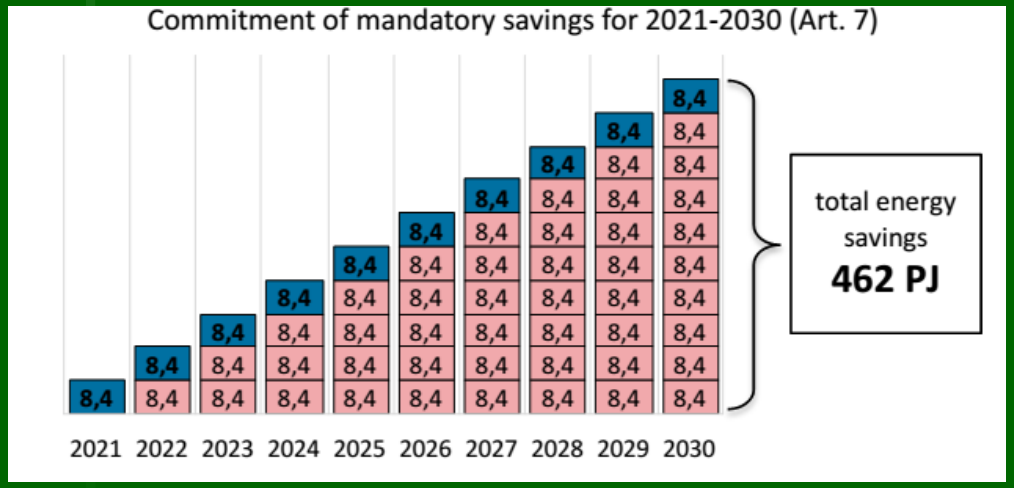
# Key EU legislation 4

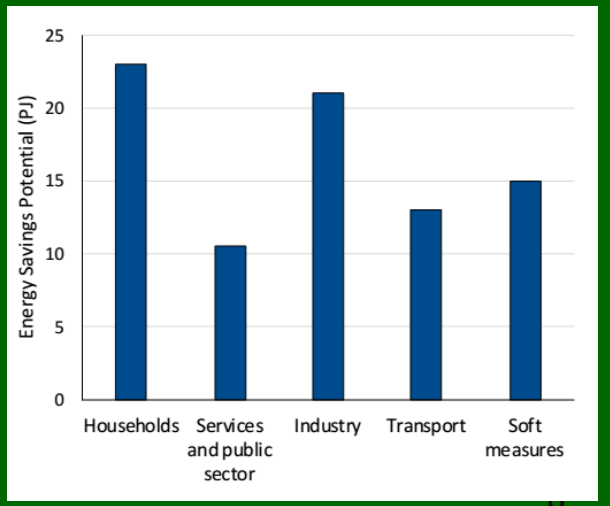
annual energy savings of 8,4 PJ – total of 462 PJ cumulative energy savings until 2030

Further tightening of mandatory annual savings => 204 PJ (2014-

2020) versus 462 PJ (2021-2030)

Estimated cost to reach the energy savings obligation for 2021-2030 with the current alternative scheme is more than 600 billion CZK (23 billion EUR)




Source: Sochor, MPO

# Energy Label of Building


Based on thermal losses of building (specific heat consumption)

# Consumption of energy by the premise

**Industrial premises**: typically individual consumption based, key driver is type of production and technology used (usually we concentrate to the utilization of waste heat or of waste products – so called secondary energy sources), key role of energy audit

**Office buildings**: consumption depends on quality of heat isolation (material used for walls, windows), way of heating and cooling, recuperation of energy, way of building utilization

**Block of flats**: design of the house, quality of heat isolation, efficiency of heating (and lighting) control, design of heating system, motivation of individual households to energy saving

**Individual (family) houses**: design of the house and heating system, quality of isolation material, possibility of heating (and lighting) management, individual preferences

# District heating sources

**Advantages:**

- **Cogeneration: higher efficiency of PES utilization**
- **Higher flexibility, thermal inertia of big systems – accumulation**
- **Can combine central and local sources**
- Solution for cities with high population density
- Utilization of waste heat (e.g. from industry)
- Cleaning devices

**Disadvantage**

- High investment cost
- Long investment period (high risk)

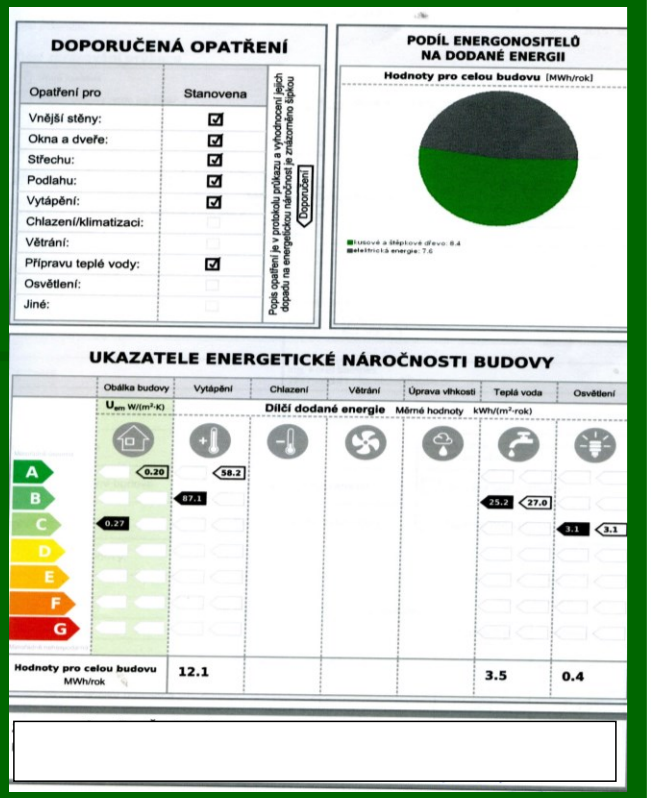
# Energy for family house

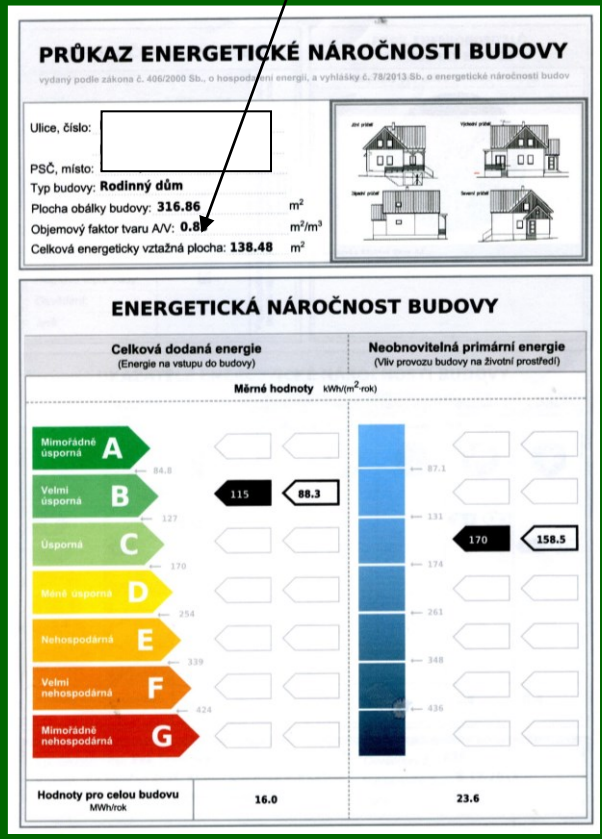
**Note: is similar to all other types of buildings**

compactness: 0,2 to 1,2

**ENERGY FOR:**

- space heating
- hot water preparation
- lighting
- cooling
- air ventilation
- humidity management



# Examples of U coefficients

**Heat losses of the building depends on among other on its design and construction material used**

**U - Heat transfer coefficients: W/(m$^2$,K):**

• lower is U value of given material, the more slowly heat is able to transmit through it (given material is better heat insulator)

Examples:

• concrete 20 cm: 3.3

• brick 30 cm: 1.7

• polystyrene 30 cm: 0.12

Old windows: up to 2.7

Double insulated glazing 24 mm with argon filling: 1.1

Triple insulated glazing 36 mm with argon filling: 0.7

See: https://www.stavebnictvi3000.cz/vypocty/vypocet-soucinitele-prostupu-tepla-a-tepelneho-odporu-steny

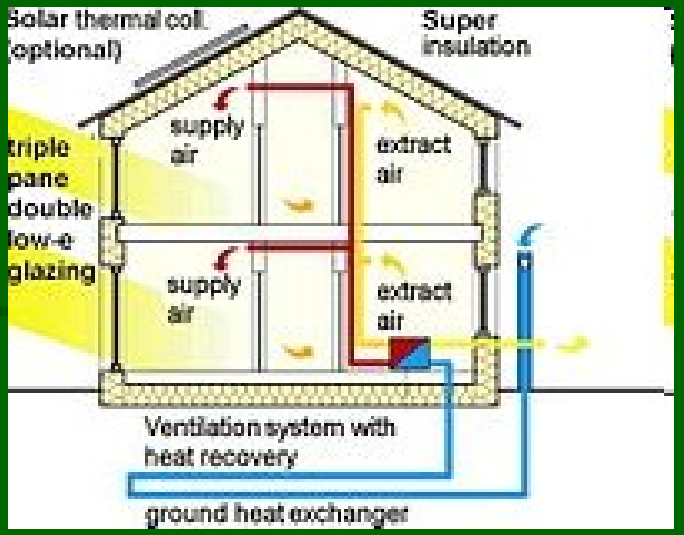
# Energy demand for heating

**Total energy losses of the building: sum of individual contributions (walls, windows, roof, etc.)**

Total value expressed in kW (depends also on size of building) for given reference temperature (e.g. -12 C)

Classification of the building

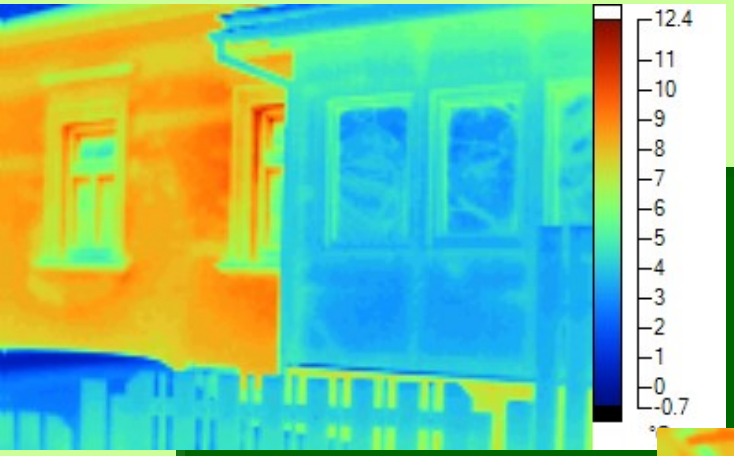
- low energy house: 15-50 kWh/m2,a
- passive house: less than 15 kWh/m$^2$,a

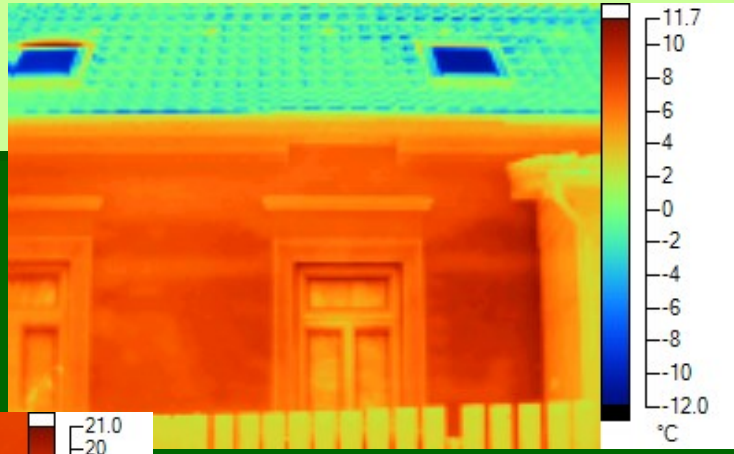


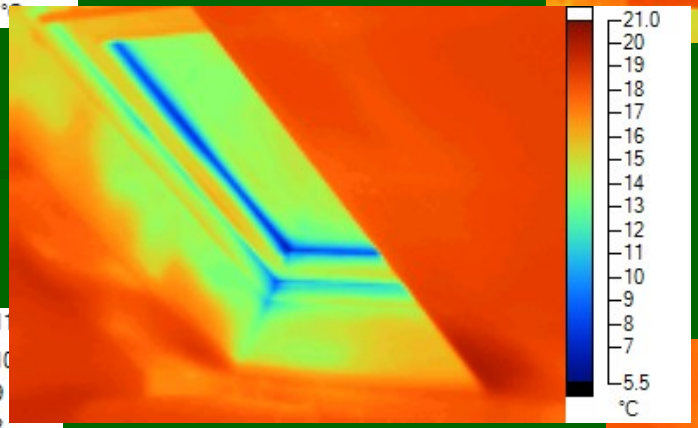

- 70-80ies: >200 kWh/m$^2$,a
- current standard houses: 80-120 kWh/m$^2$,a

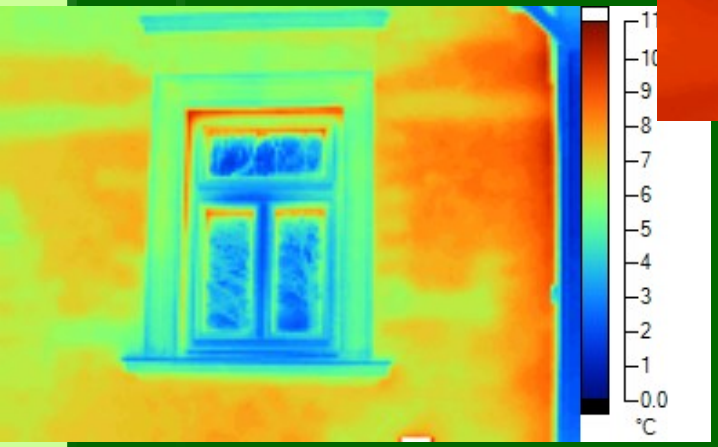
(we can calculate total heat demand in GJ using physical equivalent)

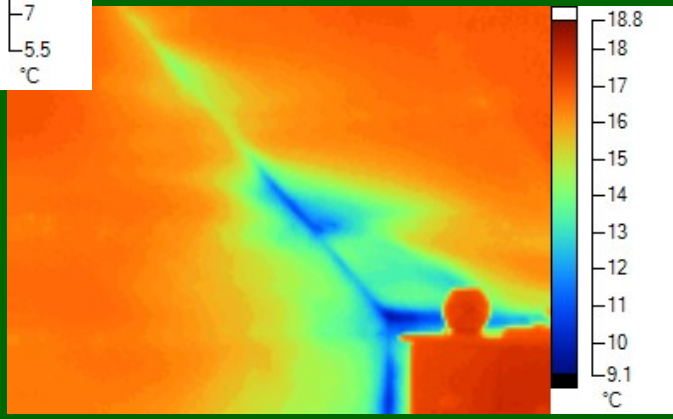
# Energy demand for heating



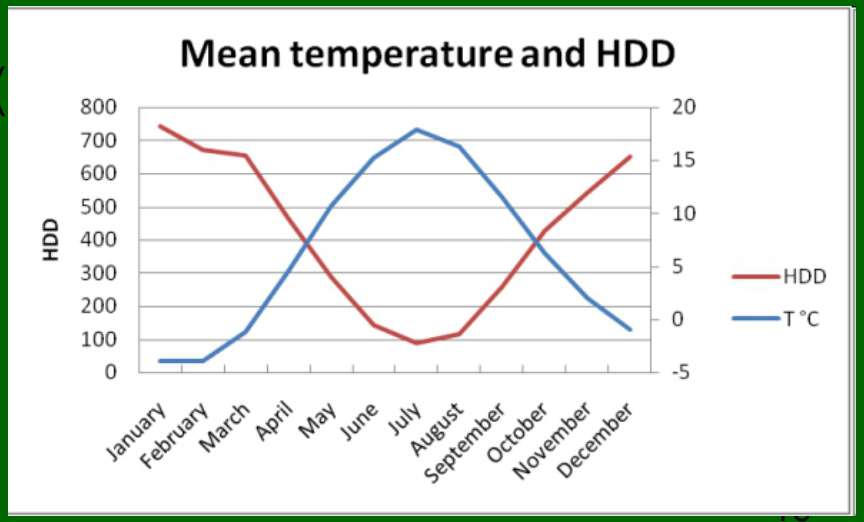
# Energy for heating

**Heating degree days – HDD**

• heat demand also depends on inside (e.g. 18 C) and outside temperature, HDD is used as a proxy / heating requirements for a given building at a specific location are considered to be directly proportional to the number of HDD at that location

Simplified calculation of HDD: as (18 °C - Tmean) if Tmean is lower than 18 °C (heating threshold, may be different) and zero if Tmean is greater than or equal 18 °C; Tmean is the mean daily outdoor temperature, calculated as Tmean = (Tmin + Tmax / 2)

individual for each country and region ( http://www.degreedays.net/)

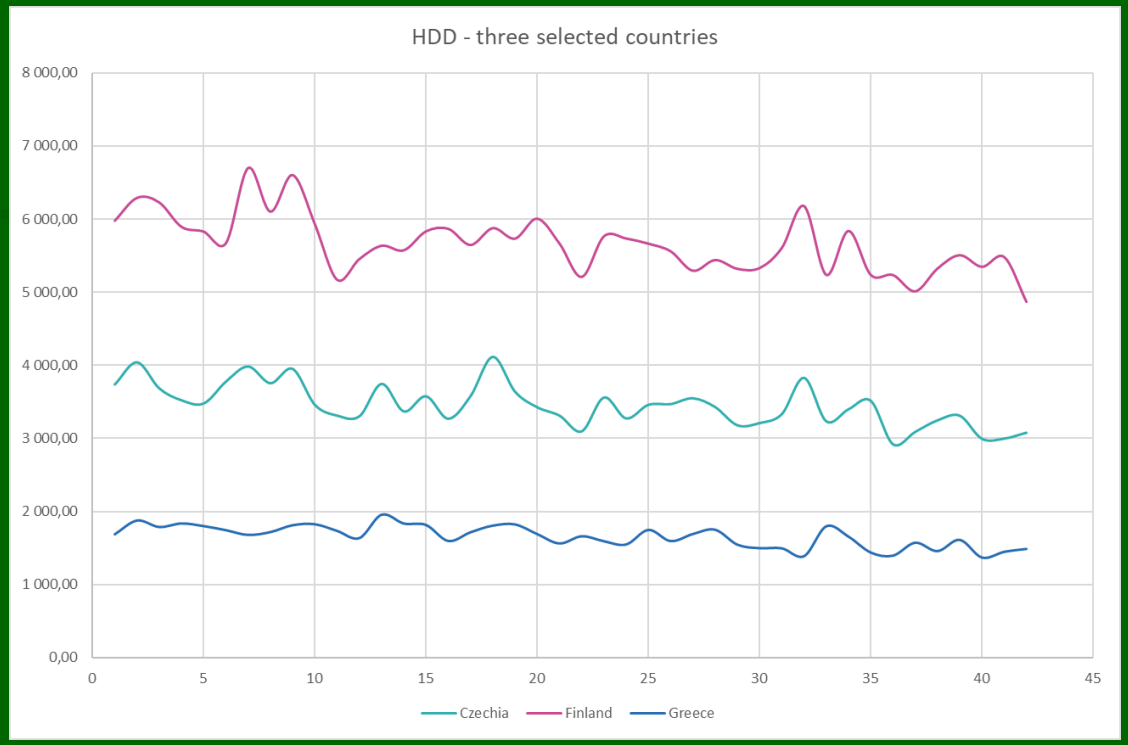


# Energy for heating 2

**Heating degree days – HDD**

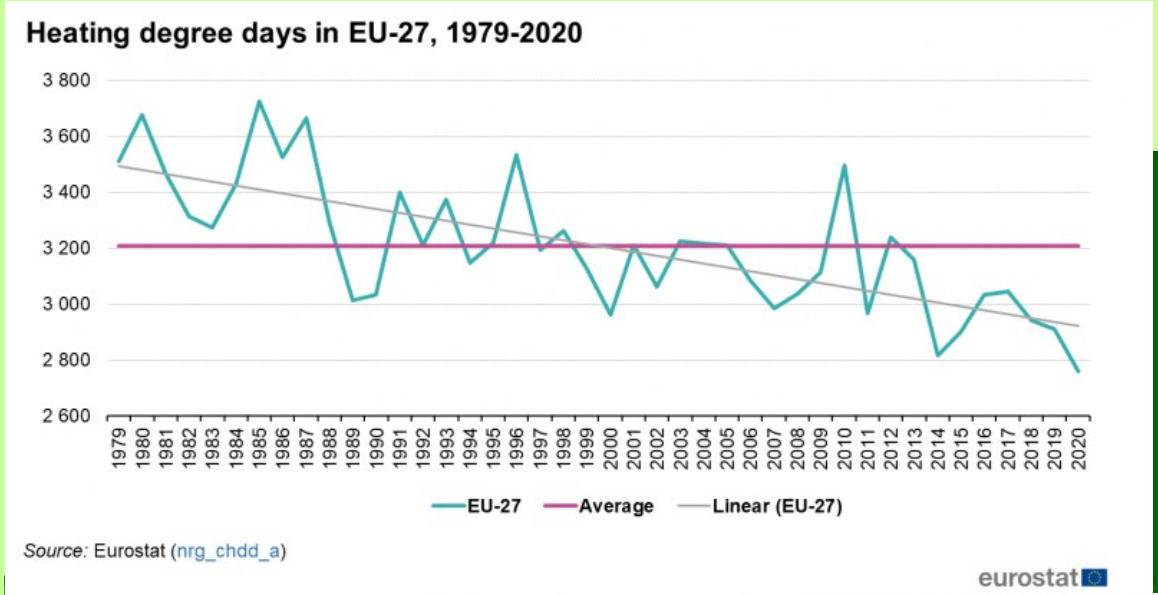
**Example for three different climate regions and EU**

(see http://ec.europa.eu/eurostat/data/database?node_code=nrg_chdd_a)



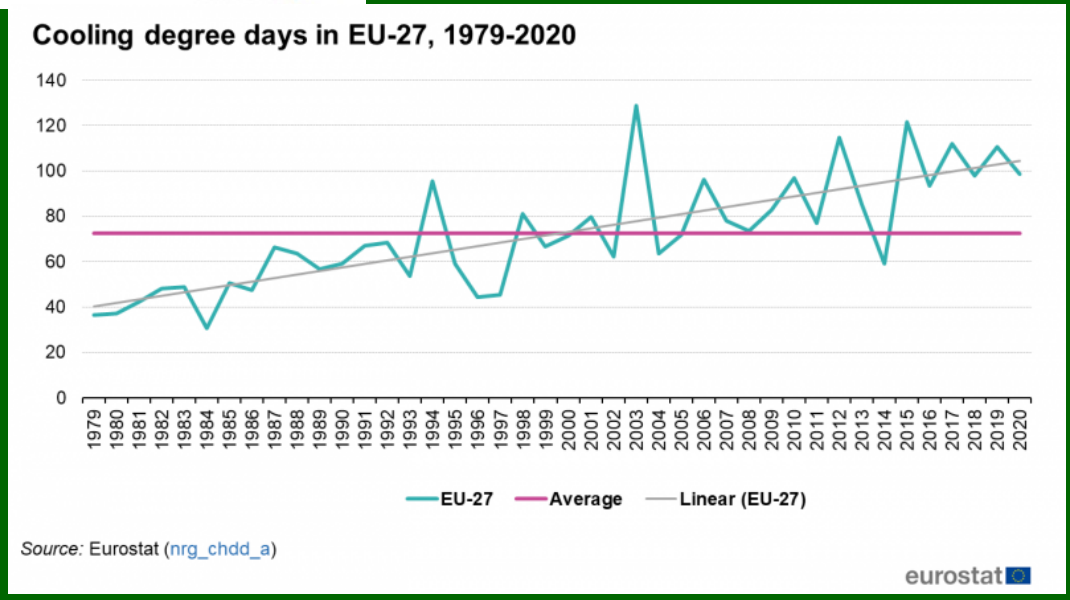
# Energy for heating 3

Heating degree days value decreased by 21 % /1979 and 2020 in the EU-27

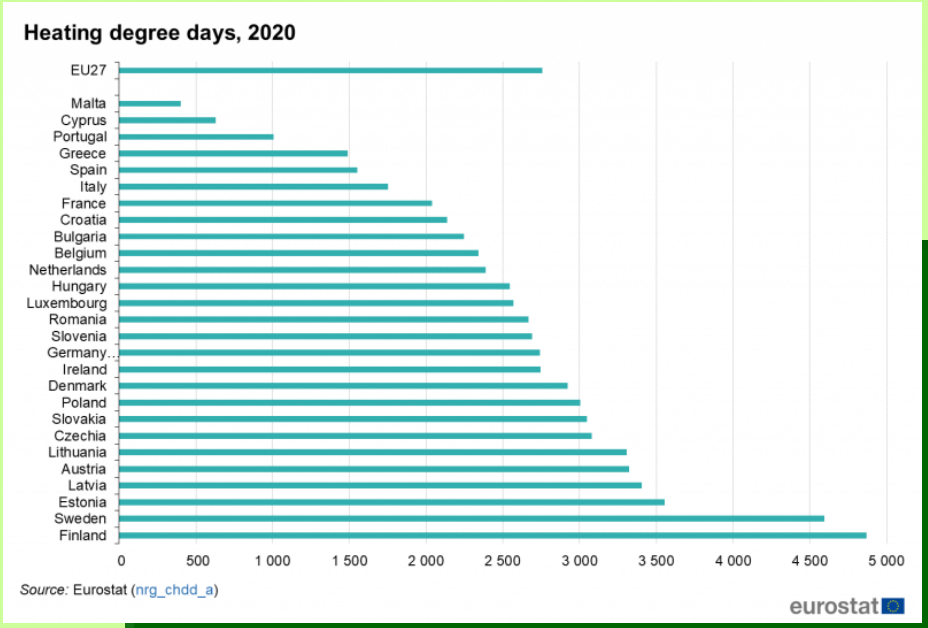


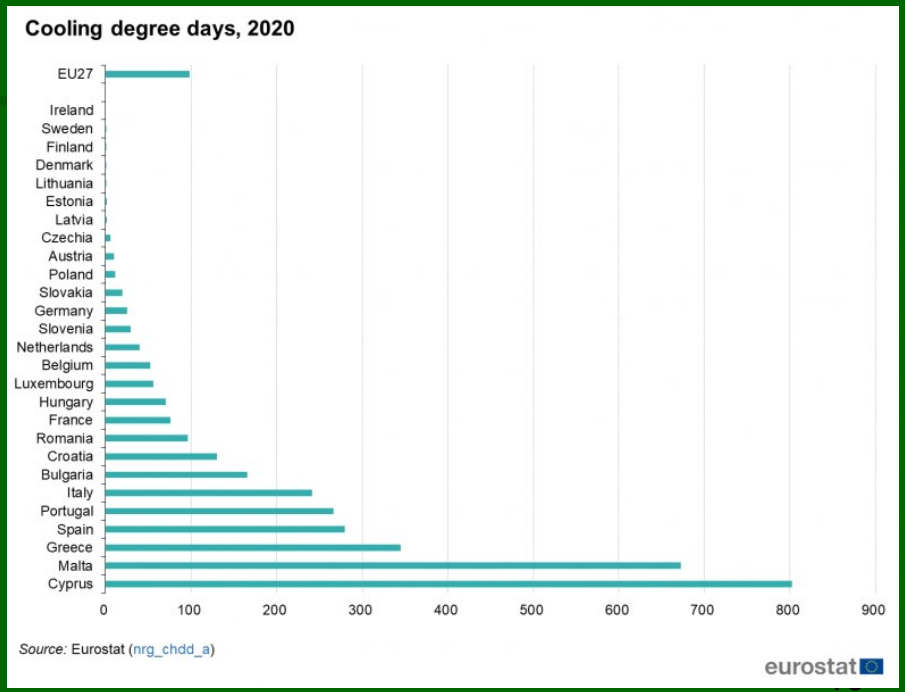

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Heating_and_cooling_degree_days_-_statistics#Heating_and_cooling_degree_days_at_EU-27_level

Cooling degree days (CDD) values in 2020 was more than two times higher between 1979 (37) and 2020 (99)



# Energy for heating 4



# Energy for hot water preparation

**Typically between 20-25% of total energy consumption of household**

- depends of behavior, number of persons, etc.
- hot water: 55 C
- hot water preparation:
  - individual system: accumulation boiler or water flow heaters (gas or electricity
  - system for heating and hot water preparation
- water consumption: highly variable (older standard app. 35 m3/person, year – app. 100 l per day)
  - toilet: 5-12 l per usage
  - shower: 20-50 l per person
  - bath: 100-150 l

# Heating a house

**Heating from District heating system:**

- central source of heat
  - heating plant
  - cogeneration plant (back pressure turbine, condensing turbine)
  - hot water or steam pipelines
- advantages:
  - higher utilization of primary energy and lower $CO_2$ emissions
  - lower conventional emissions (e.g. desulphurization units)
  - easy to use at consumption point
- disadvantages:
  - high investment cost and higher portion of fix cost – mortal spiral when energy savings are massively introduced at consumers side in existing DHS

# Heating a house

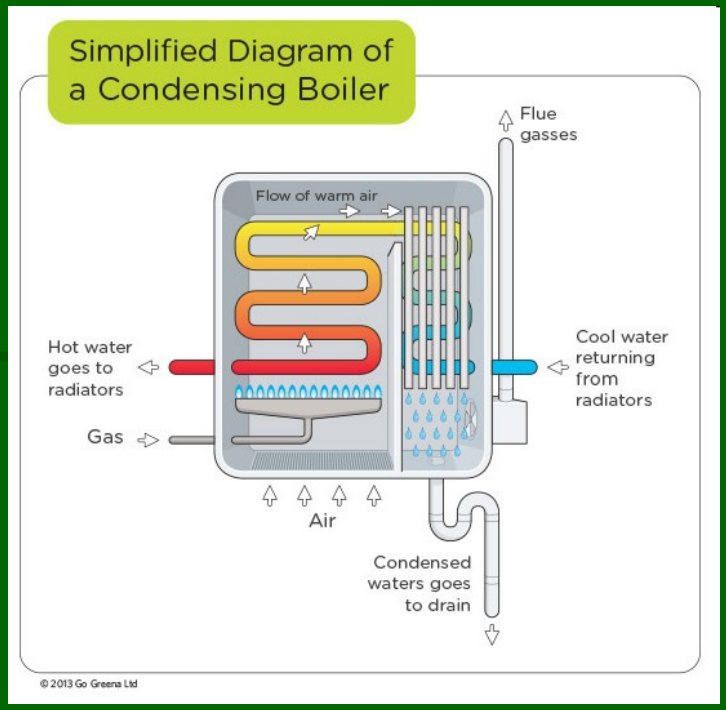
**Central boiler for building (family house) – efficiency of typical heating devices**

- natural gas
  - conventional: up to 90%, but old one can have only 65-75%
  - condensing: up to 105%

waste heat in flue gases to pre-heat cold water entering the boiler.

Lower temperatures of heating water

Outflow of condensate water



# Heating a house

**Central boiler for building (family house) – efficiency of typical heating devices**

- coal boiler
  - conventional (old): 66% (sometimes misused for waste burning)
  - modern: regulation of efficiency: 73%, since 2018: 82% (automatic delivery of coal into boiler)
- pellets boiler: 92% (also advantage in very low amount of ash)
- electric boiler
  - with or without accumulation
  - accumulation can cover energy requirement when boilers is switched of in period of low tariff (if available)
- wood boiler: 75-85% (depends on class)
  - HV of wood depends of moisture content, dry wood needed

# Heating a house

**Heat pums**

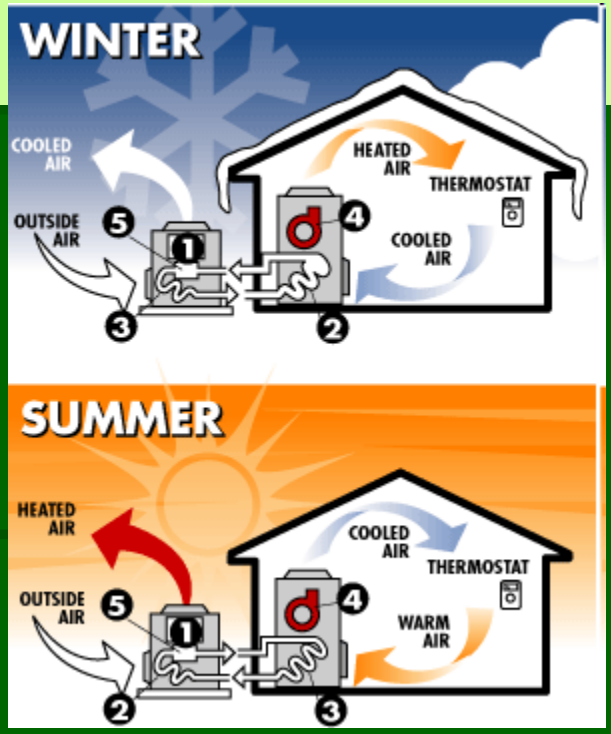
- air – water type
- water - water type
- ground – water type
- installed power in $kW_{th}$ to cover

majority of heating season

- collection of energy from outer space
- coefficient of performance
  - depends on type
  - depends on outer temperature

  and temperature of produced heat

  3 to 5



# Solar energy for heating and hot water

**Usually hybrid system**

• design to cover all energy requirement of house would lead to extremely ineffective economic solutions

• PV for hot water has advantages in no effect to power grid

• solar thermal collector – effective way but troubles with heat consumption in summer period (e.g. to cool by pool or special design is needed)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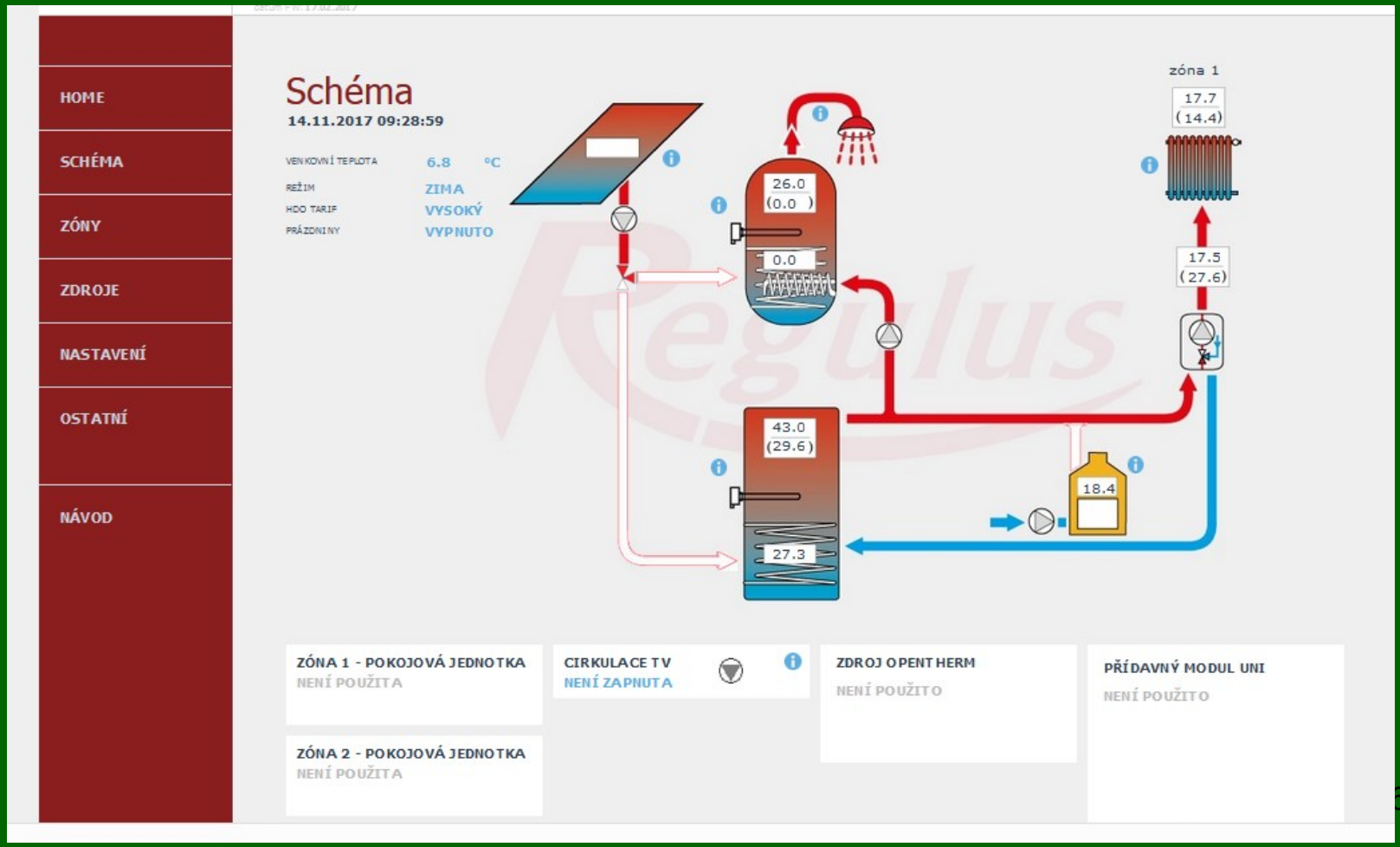
# Hybrid system for heating and hot water

**Example of hybrid system combining biomass stove with accumulation into water and electric heating**



# Thank you for attention