# Czech-Austrian Winter and Summer School (Building-Retrofit-Policy)

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## Content

## 1. ABSTRACT

It is stated that the buildings sector represents approximately 40% of the EU's total energy consumption. The implementation of appropriate policies as well as incentives for building modernization can reduce the amount of energy demanded enormously. Our motivation is to look if the current policies for building efficiency can achieve the preferred energy saving potential. Therefore current building retrofit policy implementation process will be analyzed and a comparison between Austria (AT) and Czech Republic (CZ) carried out. Building investments can bring several benefits: energy cost savings, economic as well as ecological benefits, increase of comfort as well as property value or using the advantage of coupling effects. In our paper, we focus on existing building inventory, because this segment has a large potential for reducing energy consumption. Data from EPISCOPE database is taken and a comparison of different refurbishment actions in AT and CZ compared. Single-family households and advanced refurbishments show the best energy saving potential, the refurbishment performance in AT seems to be better than in CZ. Also real experienced data from AT is compared with Episcope. The former shows lower avoided heating costs after a thermal-energetic refurbishment, which is quite an interesting result. Both of the countries have implemented EU policies well considering energy-efficiency or CO2 reduction goals. The handling between landlords and tenants for renting has to be more considered in EU law, as it is currently mostly regulated in the own country by a tenancy law.

## 2. INTRODUCTION AND PROBLEM STATEMENT

Nearly all activities by human beings are related to energy consumption. This is actually not a problem if no harm to others is being performed. But energy consumption is often linked with negative environmental impacts or societal conflicts. The run for resources in our world is still continuing without limit and with respect to our ecosystem and climate. The major trouble with energy consumption today is the associated emission of substances that have a negative impact to our earth and life on it. An indicator of our energy-hunger is the world-wide increasing CO2 emissions which are obviously deeply interrelated to human activities (see figure below).

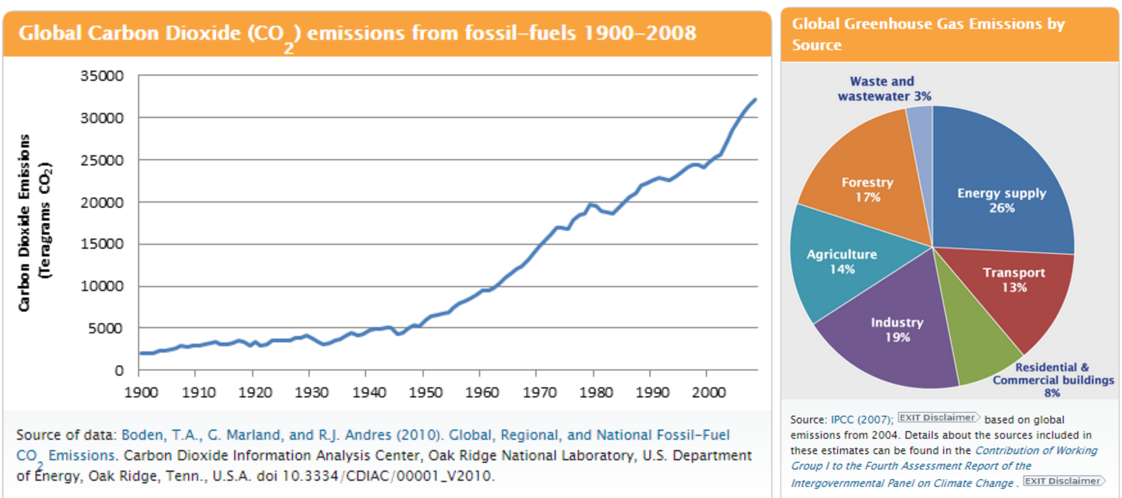


**Figure 1:** Worldwide CO2-Emissions

It is stated that the building sector represents approximately 40% of the EU's total energy consumption. Households with a share of 26%, transport 32% and industry with 25% are the three top sectors that consume energy [1], [2]. In Germany the share of energy for heating with regard to private households is nearly 80%[1]. In Czech Republic the share of fossil-fuels for energy consumption is still very high and in Austria 50% of the energy for heating and cooling comes from fossil-fuels, too.

In a broader sense, the problematic of bringing more sustainability in our living environment can be termed as carbon lock-in. It states that carbon-based energy system *"have undergone a process of technological and institutional co-evolution, driven by path-dependent increasing returns to scale"* [3]–[5]. In a narrow sense lock-in can be defined as *"structural barriers in technological transition processes that prevent new or sustainable technologies to diffuse and compete on markets, although these carbon-free energy sources are already available. The challenge is to overcome these barriers to reach future sustainability goals. This is interlinked with high switching costs…"*[6]. From this concept and the objective to reach more energy and resource awareness, energy-efficient measures like the retrofit of buildings can be seen as key element or promoter to future sustainable climate and energy goals. As building retrofit has a high energy saving potential, a major objective of the European Union is that every Member State reaches this preferred energy and climate goals as soon as possible [7]. Technology is already available and competitive on markets. There is also a subsidy scheme established for retrofitting buildings that helps to increase the currently low modernization rate. The implementation of appropriate policies as well as incentives for building modernization can reduce the amount of energy demanded enormously[2]. An interesting study on avoided costs on greenhouse gas emissions shows that building refurbishment actions have a huge potential on the reduction of CO2-emissions[3]. But for the major measures on buildings (exterior wall, windows, roof) there were positive avoided costs determined. For the authors this means indeed an ecological effectivity, but also higher costs for these measures compared to the usage of a bicycle instead of a car or an efficient road lightning for instance. Building modernizations are cost-effective and have a long amortization time [8].

However, the benefits if investments in a thermal-energetic refurbishment can be summarized in:

- energy cost savings
- economic as well as ecological benefits (CO2-reduction)
- increase of comfort and property value
- jobs
- coupling effects[4]

In this work we will take a deeper look on policies for building modernization in AT and CZ and its deduction from EU directives. A comparison between AT and CZ will be carried out

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[1] Deutsche Umwelthilfe, 2013, Energetische Gebäudesanierung? Ja, bitte

[2] Depending on extend of insulation

[3] Here focused on the reduction of CO2-emissions in Upper Austria until 2030

[4] The additional costs of a thermal insulation only is about 30% to 40%, the modernisation of the existing structure has to be done as well and is necessary.

by literature research and expert interviews. Another point of interest in this report is the potential for building retrofits in both countries. The focus will be on existing building inventory, because this segment has a large potential for reducing energy consumption.

From the EU project episcope/tabula quantitative data from AT and CZ is being analysed and different refurbishment measures are compared. In a third step experienced results of building retrofits in Austria are shown. It describes the performance of different thermal-energetic refurbishment measures of about 88.000 cases. For a chosen example the real experienced data will be compared to episcope/tabula.

## 3. Motivation: Relevance of Thermal-Energetic Refurbishment Actions

This chapter tries to answer the question, why refurbishment actions are relevant to reach future climate and energy goals. Four indicators will be treated:

- Development of the building stock to see inefficiencies (high energy demand)
- Country-specific energy demand and the relevance of private households in energy consumption
- Amount of expenses of the households is analysed to show that a lot of money can be saved if a comprehensive building modernization is carried out.
- Greenhouse gas emissions: What amount are households/buildings emitting?

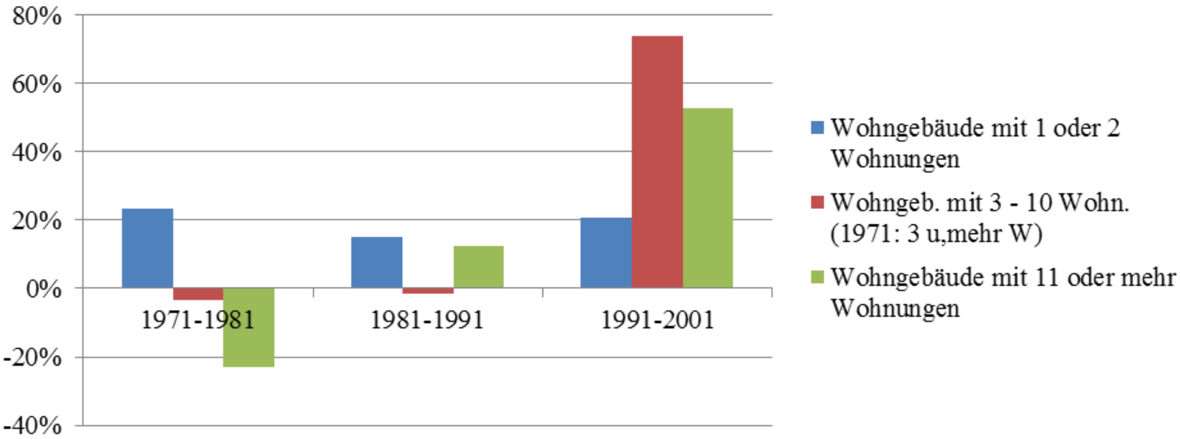
Summary:

For both countries we have seen that there are some building types that have high CO2 emissions. The expenses for heating are also an indicator for the relevance a refurbishment action. Especially buildings with a high heating demand and old heating systems exhibit high costs. There are also many buildings that are potentially adequate to-be retrofitted, especially the huge amount of single-family houses. It is also interesting that the final energy demand has remained constant in Austria since 1996, but the greenhouse emissions reduced by about 18%. The demand for space heating is projected to reduce by 20% by 2050, whereas the energy needed for cooling will increase. For new buildings the European Building Directive (2010/31/EU) will demand “nearly zero energy” buildings [9].

**Development of the building stock:**

The number of dwellings increased since 1961 from 2.2 million to 4.4 million in 2011. The development of different building types shows that in the 70ies and 80ies building with more than 3 dwellings decreased. Single family houses always increased in Austria. From 2000 the number of multi-family houses as well as apartment blocks increased (figure below)[5].

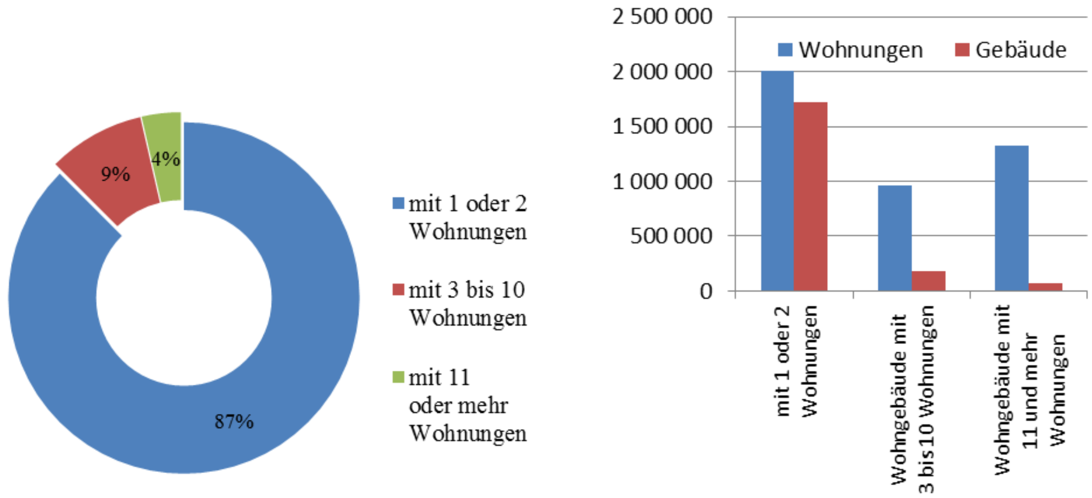
[5] It has to be stated that new buildings consume less energy than those built before 1990




Source: Statistik Austria, Registerzählung 2011

**Figure 2:** Change in the building stock (%) in Austria

In Austria about 87% of all buildings are single-family houses, whereas only 4% are houses with more than 11 apartments (see figure below). But more than 50% of the apartments are in buildings with 3 or more flats.

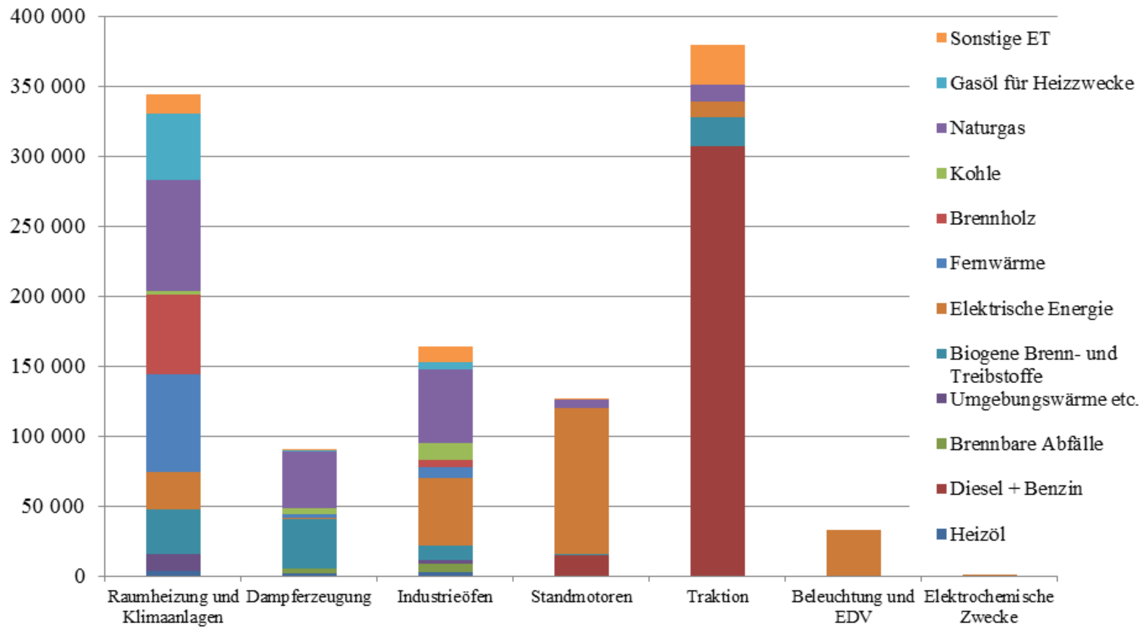



Source: Statistik Austria, Registerzählung 2011

**Figure 3:** Building stock in Austria 2011

**Energy demand:**

The figure below shows the energetic final consumption of energy by sectors and energy sources in Austria in 2013. The sector heating and cooling accounts for nearly 30% of Austrian's final energy demand with 14% of greenhouse gas emission. Half of it is covered by fossil-fuels. A view on the annual development shows a decreasing trend of heating and cooling (share), but a small increase in the absolute amounts.




Source: Statistik Austria, 2015

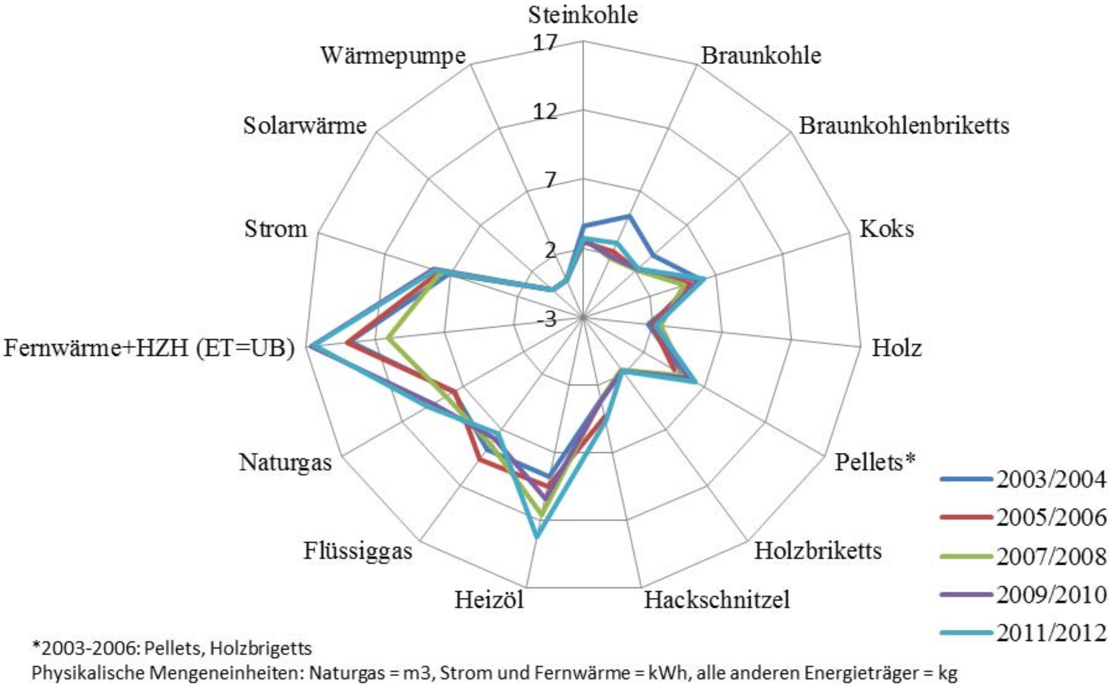
**Figure 4:** Final energy consumption 2013 by sectors and energy source (TJ/a)

The absolute values of energy demand of the private households were constant, the demand related to the floor area for space heating and hot water was steadily decreasing. Whereas the demand for space heating was on average 156 kWh/m²a, in 2010 it slightly reduced to 148 kWh/m²a.

**High expenses for energy in Austria:**

The expenses of Austrian's households can be summarized in [10]:

- Each of the 3.6 Mio. households in Austria spent per year approximately 2.840 Euro on energy consumption
- 32% belong to space heating
- Energy prices are increasing steadily
- Expenses for renewables vary between 0 and 5 Euros/m², in contrast the expenses for fossil-fuels like oil or gas as well as electricity vary between 7 and 13 Euro/m²




Source: Statistik Austria, Energiestatistik - Gesamteinsatz aller Energieträger – Mehrfachzählungen möglich, 2015

**Figure 5:** Expenses of the private households in Euro/m²by energy source from 2003-2012

### Heating costs in AT and CZ (TABULA concept[6]):

The reduction of heating costs is the main benefit of building retrofitting. The table below shows the current heating costs in the existing building stock without thermal-energetic refurbishment. There is a high potential of energy costs savings if a refurbishment action is undertaken.

[6] More information on the TABULA concept the official webpage: http://episcope.eu/building-typology/overview/ (accessed June 2015)

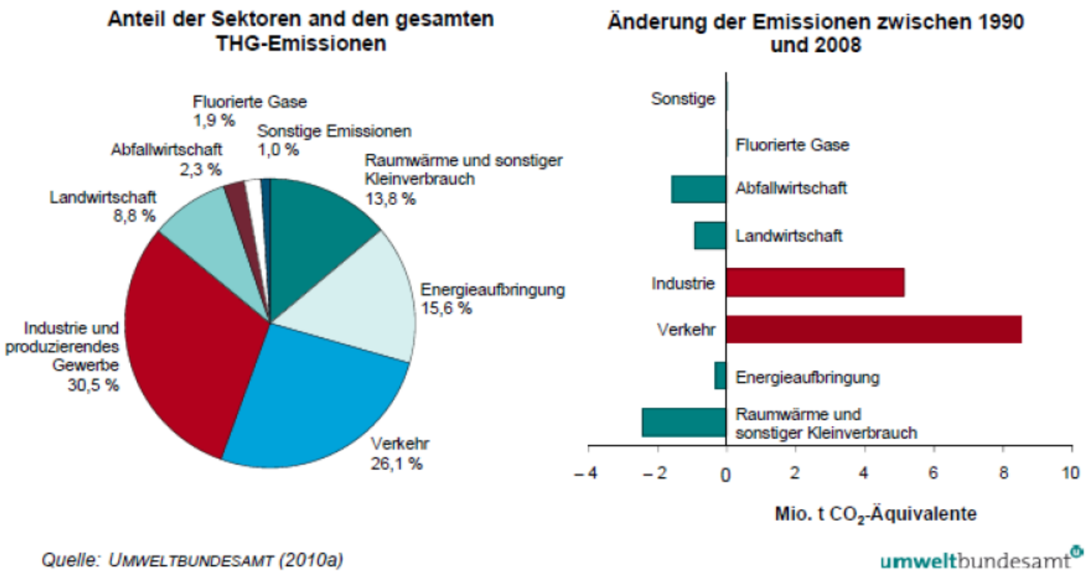
**Table 1:** Heating costs by building type and age in Euro/m²a in AT and CZ

| Austria | | | | | | |
|---|---|---|---|---|---|---|
| | Apartment Block | | Multi Family House | | Single Family House | Terraced House |
| *Source:* | *Gas* | *District Heating* | *Gas* | *District Heating* | *Oil* | *Oil* |
| until 1920 | 20,9 € | 16,8 € | 24,5 € | 20,5 € | 39,2 € | 25,0 € |
| 1921 - 1945 | 19,1 € | 15,0 € | 26,6 € | 22,7 € | 35,1 € | 26,7 € |
| 1946-1960 | 21,2 € | 17,1 € | 24,1 € | 20,1 € | 24,0 € | 31,7 € |
| 1961-1980 | 17,4 € | 13,3 € | 22,0 € | 17,9 € | 28,9 € | 28,6 € |
| 1981-1990 | 10,8 € | 6,5 € | 15,6 € | 11,4 € | 18,2 € | 21,0 € |
| 1991-2005 | 12,9 € | 8,6 € | 13,4 € | 9,2 € | 14,5 € | 15,4 € |
| **Czech Republic** | | | | | | |
| *Source:* | *Gas* | *District Heating* | *Gas* | *District Heating* | *Electricity* | *Electricity* |
| until 1920 | 20,0 € | 16,8 € | 25,1 € | 21,9 € | 61,6 € | 48,0 € |
| 1921 - 1945 | 20,8 € | 17,5 € | 25,5 € | 22,3 € | 48,3 € | 34,4 € |
| 1946-1960 | 25,0 € | 21,7 € | 28,3 € | 25,0 € | 37,8 € | 31,4 € |
| 1961-1980 | 17,4 € | 14,1 € | 15,2 € | 11,8 € | 36,7 € | 27,8 € |
| 1981-1990 | 14,3 € | 10,9 € | 19,0 € | 15,6 € | 26,8 € | 19,6 € |
| 1991-2005 | 12,8 € | 9,4 € | 12,3 € | 8,9 € | 22,0 € | 15,7 € |

Source: http://episcope.eu; own calculations, 2015

### Greenhouse gas emissions in the Austrian building stock:[9]

The sector space heating contributes with 14 % to the Austrian greenhouse emissions and is low compared to the 28 % of the final energy demand, although the high share of biomass and district heating[7]. [9]. A decreasing tendency of greenhouse gas emissions of the private households between 1990 and 2008 could be experienced. This can be explained in a shift to less emitting sources like district heating and renewable energy carriers.

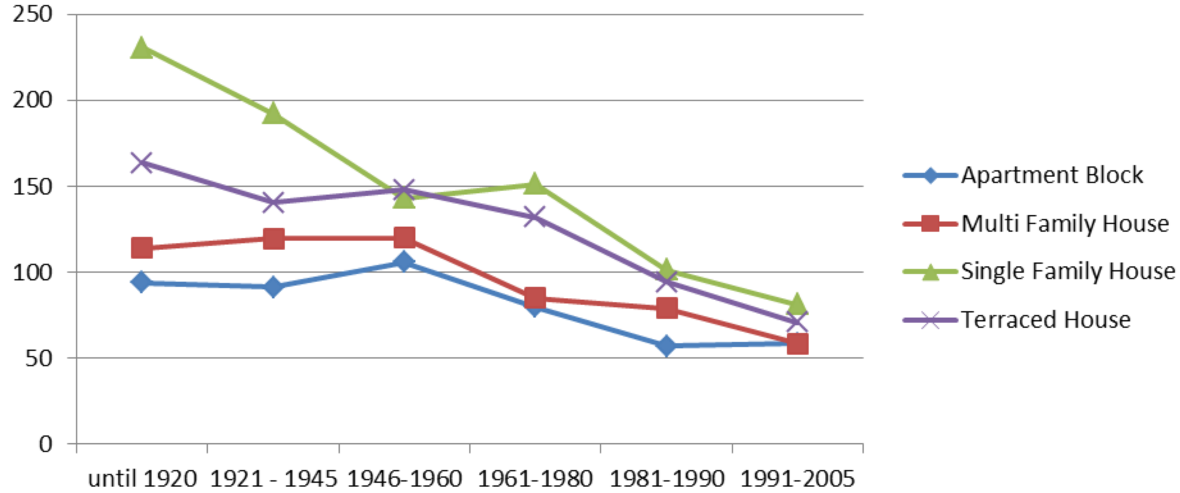



Source: Umweltbundesamt 2009, 2011, 2012)

**Figure 6:** Greenhouse gas emissions of different sectors in million t CO2 equivalent/year in Austria

[7] The production of district heat and electricity belongs not to households in the statistics

In 2009 the emissions were with 10.3 mio t $CO_2$ in the range of the Austrian goals of the Kyoto protocol[8]. The observed increase in 2010 to 11.4 mio t/$CO_2$ can also be due to weather conditions. In the Austrian climate strategy a goal value of 11.9 mio t $CO_2$ equivalent/a was prescribed for 2009 and 2010. The goal for 2020 in the Austrian climate law (Klimaschutzgesetz) sees a reduction to 8.65 mio t $CO_2$ equivalent/a by 2020 [9][9].




Source: http://episcope.eu; own calculations, 2015

**Figure 7:** Average $CO_2$-emissions for heating and hot water[10] (kg/m²a) in AT and CZ

TABULA shows (figure above) that the highest $CO_2$ emissions can be observed in single-family and terraced houses, as they have a lower outer area to volume ratio as well as often more oil and gas as energy carrier. Kletzan et al. state for Austria that SFH have the highest absolute emissions from 1945 to 1980, a time when building were rebuilt cheaply and no look on energy efficiency [11]. New buildings reach very low emissions, as the criteria for subsidies demands high energy efficiency levels. According to the OIB 6 rule in future all new buildings have to go for "Nearly Zero Energy Buildings"[12].

The table below gives an overview of the $CO_2$ emissions for each country by building type and period (TABULA concept). High emissions per m² can be found in single-family and terraced houses in buildings up to 1980 in both countries.

[8] 10.5 mio t $CO_2$ equiv./a according to the Lebensministerium, 2002

[9] This report was compiled for the Austrian assessment report on climate change of the Austrian Panel on Climate Change (APCC), Volume 3, Chapter 5 in 2014

[10] SFH, TH: oil heating; MFH, AB: gas central heating – both medium efficiency

**Table 2:** $CO_2$ emissions for different building types for heating and hot water (kg/m²a) for AT and CZ

| | Apartment Block | Multi Family House | Single Family House | Terraced House |
|---|---|---|---|---|
| **AT** | **78,40** | **96,80** | **143,33** | **132,77** |
| until 1920 | 96,20 | 112,80 | 212,50 | 134,20 |
| 1921 - 1945 | 88,00 | 122,70 | 189,70 | 143,70 |
| 1946-1960 | 97,40 | 111,00 | 128,80 | 171,00 |
| 1961-1980 | 80,20 | 101,10 | 155,80 | 153,90 |
| 1981-1990 | 49,50 | 71,60 | 96,60 | 112,40 |
| 1991-2005 | 59,10 | 61,60 | 76,60 | 81,40 |
| **CZ** | **83,63** | **95,17** | **156,57** | **116,93** |
| until 1920 | 91,30 | 114,80 | 248,90 | 193,10 |
| 1921 - 1945 | 94,60 | 116,60 | 194,40 | 137,20 |
| 1946-1960 | 114,00 | 129,20 | 157,30 | 124,80 |
| 1961-1980 | 79,30 | 68,60 | 146,60 | 110,10 |
| 1981-1990 | 64,80 | 86,30 | 106,10 | 76,20 |
| 1991-2005 | 57,80 | 55,50 | 86,10 | 60,20 |

Source: http://episcope.eu; own calculations, 2015

# 4. RESULTS

## Potential of thermal-energetic refurbishment

In the European Union the characteristics of the building stock differ significantly between the Member States in terms of type, age, renovation rates, energy performance or ownership. This is the reason why an overall approach that fits all countries is not useful to-be applied by the EU and the individual countries have to ratify EU-directives (e.g.: Energy Performance of Building 2010/31/EU) in national law to find the best way to increase energy-efficiency in the building stock. From the TABULA concept national building type typologies were developed that represent the residential building stock in 16 EU Member States. This will be used for a comparison of the refurbishment potential between CZ and AT.

For AT the study "Thermische Sanierung in Österreich" by the Donauuniversität Krems shows "CO2-Emissionsfaktoren" for different building types and shows which buildings have a high potential to be thermal-energetic refurbished. Goal of this study was to evaluate the performance of the Austrian building stock towards more energy-efficiency. Input values are emissions caused by the specific type and number of buildings expressed in their used area.

The following figure shows the CO2 emission-potential for buildings differenced by object type and age. The higher the potential the worse the performance (heating demand) of the individual building.

<u>Reading Example for the following figure:</u> A single family house (SFH, EFH in German) built before 1919 has a emission-factor of 1.49. It is calculated from the share of emissions (SFH have 7.9% share of emissions) divided by the share of used area[11] (SFH use 5.3% of the whole area used for all buildings). The study shows that buildings built between 1945 to 1960 show the worst performance. Refurbishments would effect a high energy saving, whereas apartment blocks (AB; "WHA" in this figure) from 1991 have a quite good performance.

| | vor 1919 | 1919 - 1944 | 1945 - 1960 | 1961 - 1970 | 1971 - 1980 | 1981 - 1990 | 1991 - 2000 | ab 2001 | total |
|---|---|---|---|---|---|---|---|---|---|
| EFH | 7,9% : 5,3%<br>**1,49** | 4,9% : 3,1%<br>**1,58** | 9,3% : 5,1%<br>**1,82** | 8,7% : 5,9%<br>**1,47** | 6,4% : 7,7%<br>**0,83** | 4,9% : 6,8%<br>**0,72** | 3,9% : 7,7%<br>**0,51** | 1,6% : 4,9%<br>**0,33** | 47,5% : 46,4%<br>**1,02** |
| ZFH | 3,0% : 2,0%<br>**1,50** | 1,5% : 1,0%<br>**1,50** | 3,9% : 2,2%<br>**1,77** | 4,3% : 2,9%<br>**1,48** | 2,3% : 2,8%<br>**0,82** | 1,2% : 1,6%<br>**0,75** | 0,6% : 1,3%<br>**0,46** | 0,2% : 0,6%<br>**0,33** | 17,2% : 14,3%<br>**1,20** |
| MFH | 3,4% : 2,6%<br>**1,31** | 1,9% : 1,4%<br>**1,36** | 2,9% : 1,9%<br>**1,53** | 2,7% : 2,1%<br>**1,29** | 1,0% : 1,8%<br>**0,56** | 0,8% : 1,8%<br>**0,44** | 0,9% : 2,8%<br>**0,32** | 0,5% : 1,7%<br>**0,29** | 14,2% : 16,0%<br>**0,89** |
| WHA | 3,0% : 2,3%<br>**1,30** | 1,3% : 1,0%<br>**1,30** | 1,5% : 1,0%<br>**1,50** | 2,8% : 2,1%<br>**1,33** | 1,0% : 1,8%<br>**0,56** | 0,6% : 1,4%<br>**0,43** | 0,5% : 1,6%<br>**0,31** | 0,3% : 1,0%<br>**0,30** | 11,1% : 12,1%<br>**0,92** |
| GWB | 3,3% : 2,5%<br>**1,32** | 0,8% : 0,6%<br>**1,33** | 1,2% : 0,8%<br>**1,50** | 2,5% : 1,8%<br>**1,39** | 1,2% : 2,2%<br>**0,55** | 0,5% : 1,1%<br>**0,45** | 0,4% : 1,3%<br>**0,31** | 0,3% : 0,9%<br>**0,33** | 10,1% : 11,1%<br>**0,91** |
| total | 20,6% : 14,5%<br>**1,42** | 10,4% : 7,1%<br>**1,46** | 18,8% : 10,9%<br>**1,72** | 21,1% : 14,8%<br>**1,43** | 11,9% : 16,2%<br>**0,73** | 8,0% : 12,8%<br>**0,63** | 6,4% : 14,7%<br>**0,44** | 2,8% : 9,1%<br>**0,31** | 100,0% : 100,0%<br>**1,00** |

Source: Department für Bauen und Umwelt, Donau-Universität Krems 2012

**Figure 8**: Performance of the Austrian building stock

The figure below represents the performance (expressed as heating demand in kWh/m²a) of existing buildings[12]. Structured by the built period apartment blocks (AB) absolutely have the lowest demand for heating (decreasing with continuing time). Single-family houses (SFH) need twice of the energy compared to AB built until 1960. After World War 2 the performance

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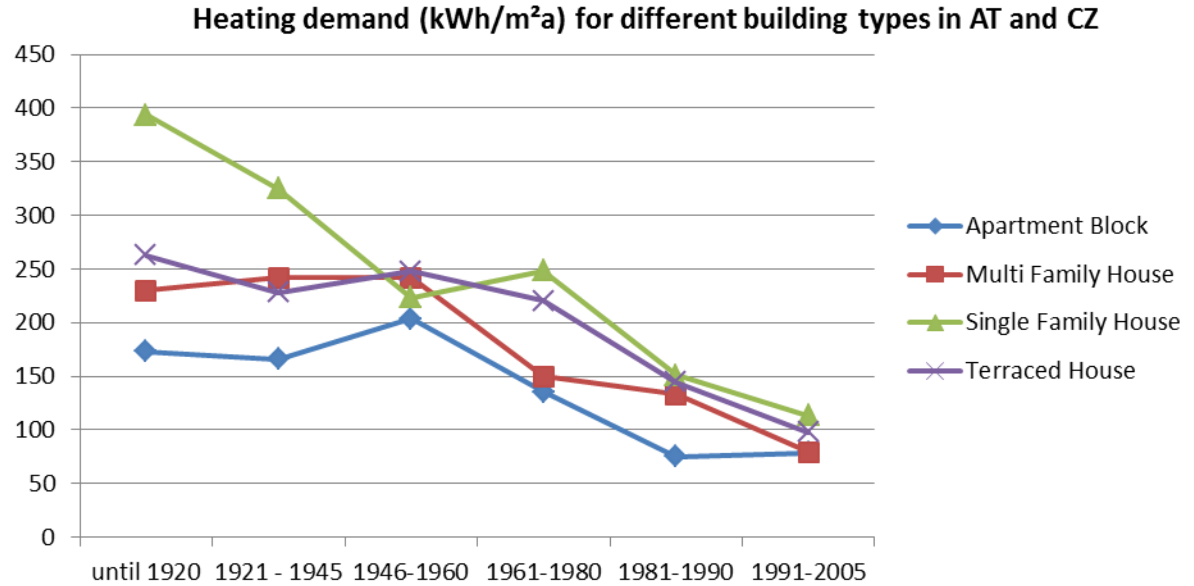
[11] This is also an indicator for the amount of buildings in this typology

[12] TABULA concept

of all houses improved, before it stagnated or worsened (except for the SFH[13]). Buildings today have a very low heating demand compared to buildings built 50 or 70 years ago. Comprehensive building retrofit measures can save a lot of energy.




Source: http://episcope.eu; own calculations, 2015

**Figure 9:** Average performance of existing buildings without refurbishment actions

A comparison of the average demand for heating (kWh/m²a) of buildings in AT and CZ (TABULA concept) is shown in the following table. It shows that single family and terraced houses built until 1980 have a bad performance in both countries. The country-specific comparison shows that old buildings in Austria have a much higher energy need than buildings in Czech Republic.

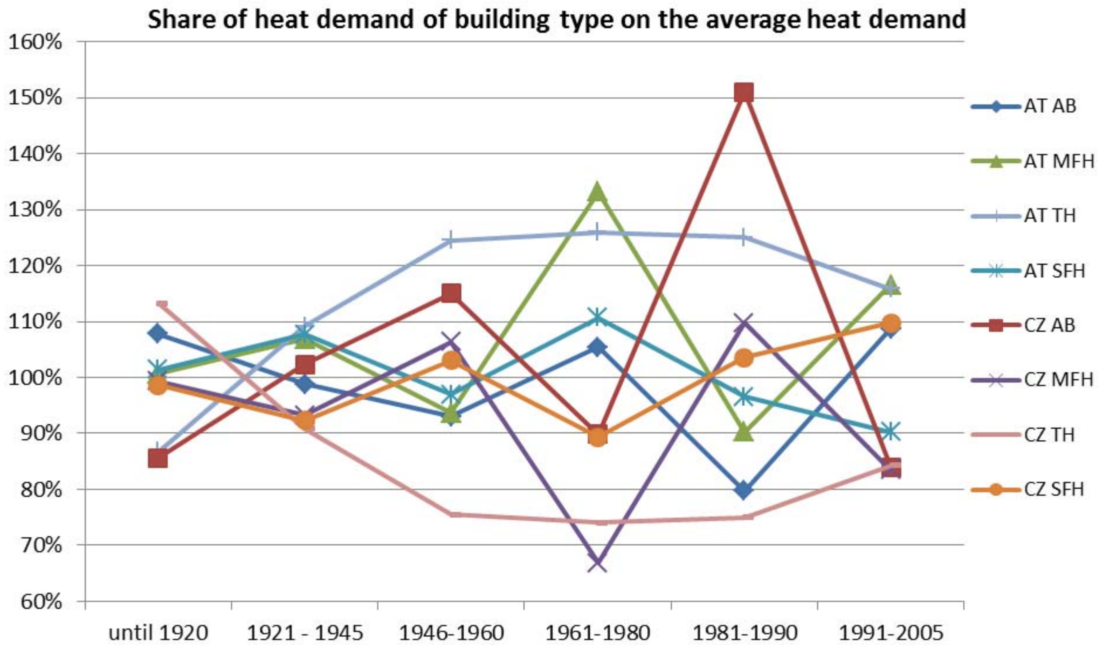
[13] This is contrary to Kletzan et al and the study by Donau Universität Krems!

**Table 3:** Demand for heating (kWh/m²a)

| | until 1920 | 1921 - 1945 | 1946-1960 | 1961-1980 | 1981-1990 | 1991-2005 | all buildings |
|---|---|---|---|---|---|---|---|
| **Apartment Block** | **172,9** | **166,1** | **203,8** | **135,7** | **75,1** | **78,9** | 138,7 |
| AT | 186,3 | 164,2 | 189,6 | 143,0 | 59,8 | 85,8 | 138,1 |
| CZ | 159,5 | 168,0 | 218,0 | 128,4 | 90,3 | 72,0 | 139,4 |
| **Multi Family House** | **230,0** | **241,8** | **242,0** | **150,0** | **132,8** | **79,6** | 179,4 |
| AT | 231,5 | 258,2 | 226,6 | 199,7 | 119,8 | 92,7 | 188,1 |
| CZ | 228,5 | 225,3 | 257,4 | 100,3 | 145,8 | 66,4 | 170,6 |
| **Single Family House** | **393,8** | **324,8** | **223,2** | **248,7** | **151,2** | **113,3** | 242,5 |
| AT | 399,2 | 349,6 | 216,3 | 275,2 | 145,9 | 102,3 | 248,1 |
| CZ | 388,3 | 299,9 | 230,0 | 222,1 | 156,5 | 124,3 | 236,9 |
| **Terraced House** | **263,0** | **228,1** | **247,8** | **220,2** | **144,3** | **97,6** | 200,2 |
| AT | 228,2 | 249,0 | 308,5 | 277,4 | 180,4 | 113,0 | 226,1 |
| CZ | 297,8 | 207,2 | 187,0 | 163,0 | 108,2 | 82,2 | 174,2 |
| all buildings | 264,9 | 240,2 | 229,2 | 188,6 | 125,8 | 92,3 | 190,2 |

Source: http://episcope.eu; 2015

If we want to see which buildings deviate from the average heating demand of both countries, the share of the country-specific building on the average heating demand was calculated. The figure below can be interpreted as followed: All values above 1 show that the heating demand is higher than the average of AT and CZ. Values below 1 show a better and therefore lower heating demand of the specific building from the average at this year. Apartment blocks in CZ built from 1981 to 1990 have 50% more energy demand (150%) than the average values of CZ and AT together, in AT apartment blocks consume only 80% of the average values of both countries.



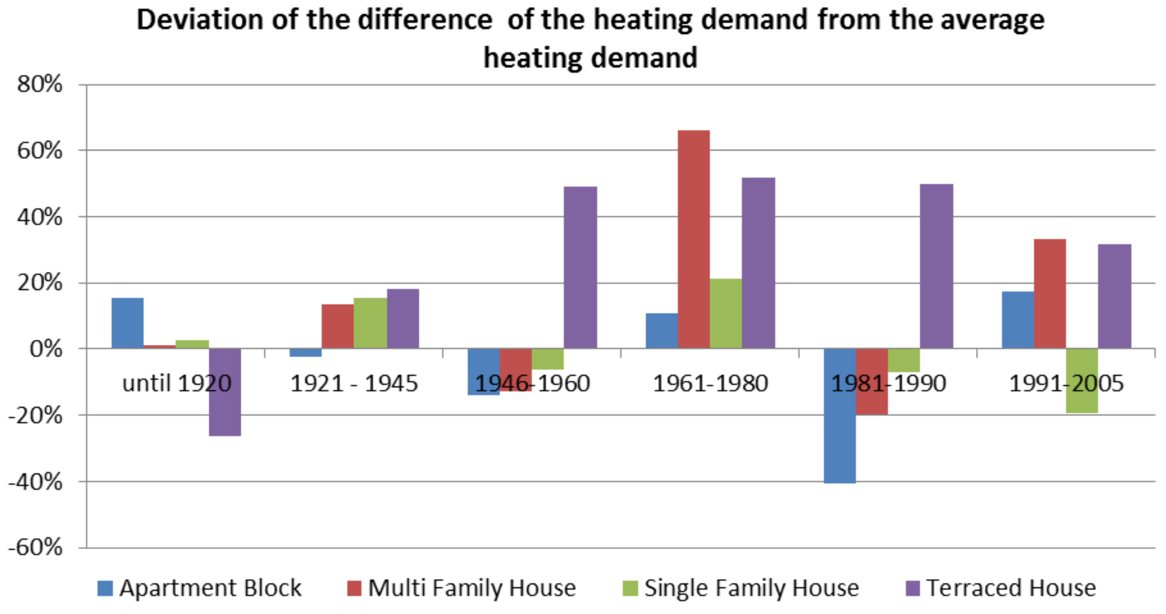

Source: http://episcope.eu; own calculations, 2015

**Figure 10:** Performance of building types in AT and CZ

The figure below shows the deviation of the country-specific buildings from the average heating demand values for Austrian and Czech buildings.

Calculation: For each building type and age the difference of heating demand between AT and CZ was calculated. Then the share of this difference on the average heating demand of the specific house and age of AT and CZ was calculated.

The y-axis shows in which country are better heating demands. The minus values in the diagram show benefits for Austrian houses compared to CZ. The bars in the positive area indicate benefits for Czech buildings in that specific age and type. Apartment blocks built between 1981 and 1990 in Austria have a better performance than Czech ones. On the other hand all building types in CZ built from 1961 to 1980 have a lower demand for heating than Austrian buildings in the same stock. The comparison is interesting and shows an overall better performance of Czech buildings. The author who is responsible for the Austrian part states that this comparison should be questioned more critically. More evaluations are necessary to prove or disprove these results.




Source: http://episcope.eu; own calculations, 2015

**Figure 11:** Comparison of AT and CZ energy need for heating

## Effects of thermal-energetic refurbishment actions

The following chapter shows the effect of building refurbishment actions in Austria and Czech Republic. The project TABULA/EPISCOPE elaborated building stock models to assess refurbishment processes and project the future energy consumption for 16 countries in the EU. Starting with building typologies, different variants of refurbishment actions have been calculated to make the energy refurbishment processes in the European housing sector transparent and effective.

TABULA represents the residential building stock according to the following elements:

- classification concept for existing residential buildings according to age, size and further parameters
- a set of example buildings which represent specific building types of the national stocks
- typical energy consumption values for the example buildings
- showcase calculations of the possible energy savings
- statistical data for buildings and supply systems[14]

A two-track approach was used to combines a national and common definition. The former is required for experts to design and handle the specific data for each country, the latter required for a comparison/exchange of data between the specific countries. For each country a specific "showcase" was designed and allows a quite good comparison. In this report the focus on Czech Republic and Austria was taken on the following aspects:

- Energy need for heating in different building types (kWh/m²a)
- Costs for heating (Euro/m²a)
- CO2-Emissions that arise (kg/m²a)

All items have been calculated for three scenarios:

1. Existing state (no refurbishment is undertaken)
2. Usual refurbishment (+thermal-energetic envelope, +better heating efficiency)
3. Advanced refurbishment (+better thermal-energetic envelope, +80% heat recovery, + solar heating); klima:aktiv standard in Austria

For the different refurbishment actions for each building type a different thermal envelope has been chosen. Refurbishments on roof, wall, window and floor are undertaken. Between usual and advanced scenario concerning the thermal envelope, differences can be seen in the u-value and thickness of the thermal insulation. Due to the many different variants for each type detailed information can be found on the webpage of EPISCOPE[15]. The following types for heating and hot water distribution for comparison of heating costs and CO2-emissions were used:

| | Single-family, terraced house | Multi-family house/Apartment block |
|---|---|---|
| Austria | oil central heating | gas central heating/district heating |
| Czech Republic | electric night storage space heater | |

[14] List taken from webpage

[15] http://episcope.eu/index.php?id=97 (accessed June 2015)

### Example: Performance of a refurbishment measure in an apartment-block (TABULA):

For AT and CZ the energy demand, heating costs, CO2-emissions, the saved heating costs and data from real experienced cases are shown in the table below. In both countries there are hardly any big differences experienced if all building periods of the apartment block are taken into account. A comparison between TABULA and real experienced cases[16] show big differences. The saved heating costs for advanced refurbishments vary between 8.2 (real data) and 15.53 (TABULA concept) Euros/m²a.

**Table 4:** Building refurbishment actions for an apartment block

| **Apartment Block** | | AT | CZ | Average AT-CZ |
|---|---|---|---|---|
| energy need (kWh/m²a) | existing state | 163,10 | 154,99 | 159,05 |
| | usual refurbishment | 74,27 | 72,06 | 73,16 |
| | advanced refurbishment | 58,24 | 58,33 | 58,29 |
| heating costs (Euro/m²a) gas central heating | existing state | 19,04 | 19,64 | 19,34 |
| | usual refurbishment | 6,83 | 8,02 | 7,42 |
| | advanced refurbishment | 3,51 | 5,15 | 4,33 |
| CO2-emissions (kg/m²a) gas central heating | existing state | 87,60 | 89,40 | 88,50 |
| | usual refurbishment | 31,28 | 35,33 | 33,30 |
| | advanced refurbishment | 14,93 | 21,78 | 18,35 |
| **saved heating costs (Euro/m²a) (TABULA)** | **usual refurbishment** | **12,22** | **11,63** | **11,92** |
| | **advanced refurbishment** | **15,53** | **14,49** | **15,01** |
| **saved heating costs (Euro/m²a) (real experience) Sanierungsscheck 2015** | **usual refurbishment (Teil 20, Teil 30)** | **4 - 7** | | |
| | **advanced refurbishment (klima:aktiv)** | **8,2 - 10** | | |

Source: http://episcope.eu; Kommunalkredit; own calculations, 2015

### Example: Performance of different refurbishment actions from real experienced cases in Austria:

For Austria, data from the national support scheme “Sanierungsscheck” (about 88,000 cases that submitted for funding) were evaluated[17] and the energy saving potential of different actions analysed. It clearly shows that comprehensive (advanced) refurbishment actions have the most energy saving potential (-62%), whereas a single-part refurbishment (e.g.: only ceiling, windows or exterior wall) only contributes for -30 to -45% reduction.

[16] Sanierungsscheck data by the KPC

[17] Internal usage only, unpublished. Approval for publication only by Kommunalkredit and BMFIT

**Table 5:** Characteristic values of refurbishment actions[18]

| | spez. HWB vor Sanierung kWh/m²a | spez. HWB nach Sanierung kWh/m²a | HWB Reduktion % | Spez. eingesparte Heizkosten/ m²a |
|---|---|---|---|---|
| Einzelmaßnahme Fenster/Türen | 140,26 | 127,39 | -9,17% | 1,05 € |
| Einzelmaßnahme Oberste Geschoßdecke | 127,81 | 106,63 | -16,56% | 1,74 € |
| Teilsanierung 10 | 148,58 | 110,64 | -25,10% | 3,53 € |
| Teilsanierung 20 | 154,70 | 104,20 | -31,35% | 4,12 € |
| Teilsanierung 30 | 197,60 | 99,08 | -47,12% | 8,05 € |
| Umfassende Sanierung | 148,94 | 48,48 | -62,02% | 8,22 € |
| **Gesamtergebnis** | **151,39** | **71,86** | **-47,53%** | **6,50 €** |

Source: Kommunalkredit, own calculations (Ifip, TU Wien, 2015)

The following table gives an overview of costs and benefits from experienced performed measures. From 2009 to 2015 2.9 billion Euros have been invested in thermal-energetic building modernizations in Austria. The average subsidy quota is about 12.6% - overall 362 million Euros have been paid as subsidy. The effect is a national-wide saving of heating costs of about 98.3 million Euros/year (1,133 Euros per case) which is 12 Euros/year for every Austrian resident that remain in the country for other investments. On average every investment cost 33,000 Euros that was funded with approximately 4,200 Euros.

**Table 6:** Costs, subsidies and saved heating costs – summary (Sanierungsscheck)

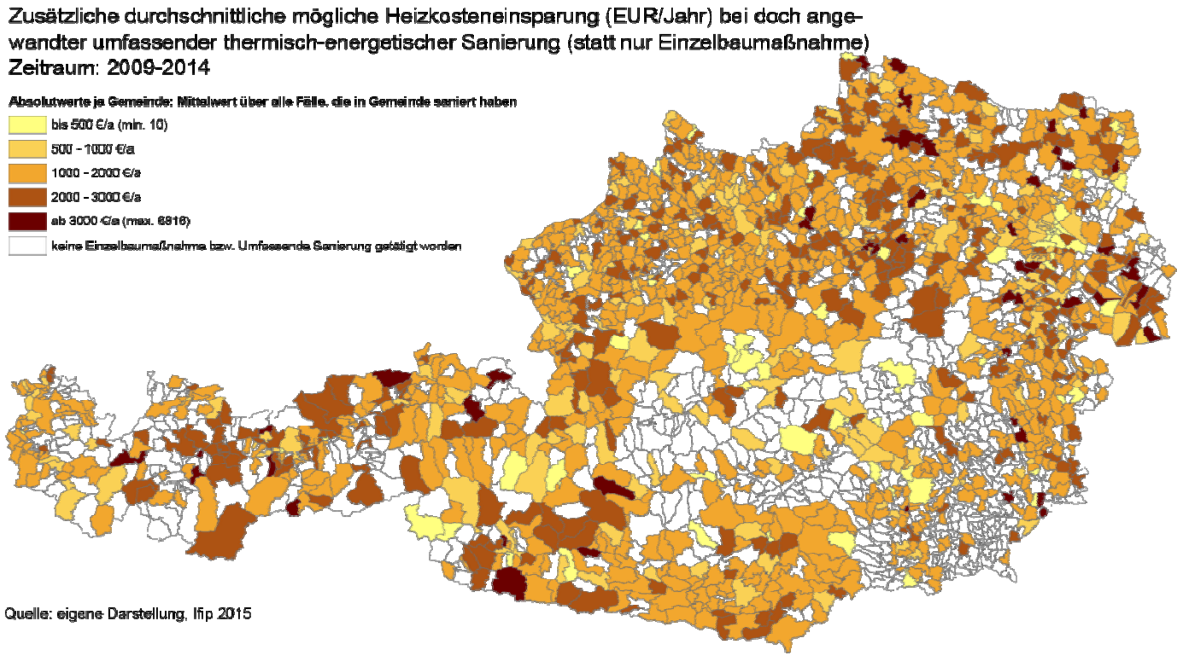
| | Investierte Gesamtkosten in therm.-energ. Sanierungen | | bezahlte Förderungen | | Eingesparte Heizkosten pro Jahr | | durchschnittliche Förderquote % |
|---|---|---|---|---|---|---|---|
| | absolut | pro Fall | absolut | pro Fall | absolut | pro Fall | |
| Einzelmaßnahme Fenster/Türen | 133 386 801 € | 15 137 € | 23 114 888 € | 2 623 € | 1 742 124 € | 198 € | 17,33% |
| Einzelmaßnahme Oberste Geschoßdecke | 33 407 760 € | 14 782 € | 4 898 040 € | 2 167 € | 693 772 € | 307 € | 14,66% |
| Veränderung Heizsystem | 46 800 899 € | 18 986 € | 4 740 006 € | 1 923 € | 0 € | 0 € | 10,13% |
| Teilsanierung 10 | 85 884 579 € | 16 970 € | 15 132 974 € | 2 990 € | 3 292 253 € | 651 € | 17,62% |
| Teilsanierung 20 | 125 701 323 € | 26 547 € | 16 220 099 € | 3 426 € | 4 163 961 € | 879 € | 12,90% |
| Teilsanierung 30 | 376 932 417 € | 32 851 € | 37 590 035 € | 3 276 € | 16 908 806 € | 1 474 € | 9,97% |
| Umfassende Sanierung | 2 057 002 568 € | 40 399 € | 259 228 349 € | 5 091 € | 71 226 336 € | 1 399 € | 12,60% |
| **Gesamtergebnis** | **2 867 846 380 €** | **33 073 €** | **362 349 844 €** | **4 179 €** | **98 253 869 €** | **1 133 €** | **12,63%** |

Source: Kommunalkredit, own calculations (Ifip, TU Wien, 2015)

The figure below shows the results if a comprehensive thermal-energetic refurbishment action would have been carried out instead of a usual measure. The result is shown for every municipality in Austria[19]. Additionally 2.3 million Euro per year of heating costs could have been saved in Austria since 2009 (heating cost saving of about 1,600 Euro/year per case).

[18] Durchschnittliche BGF der Wohneinheiten 173m².

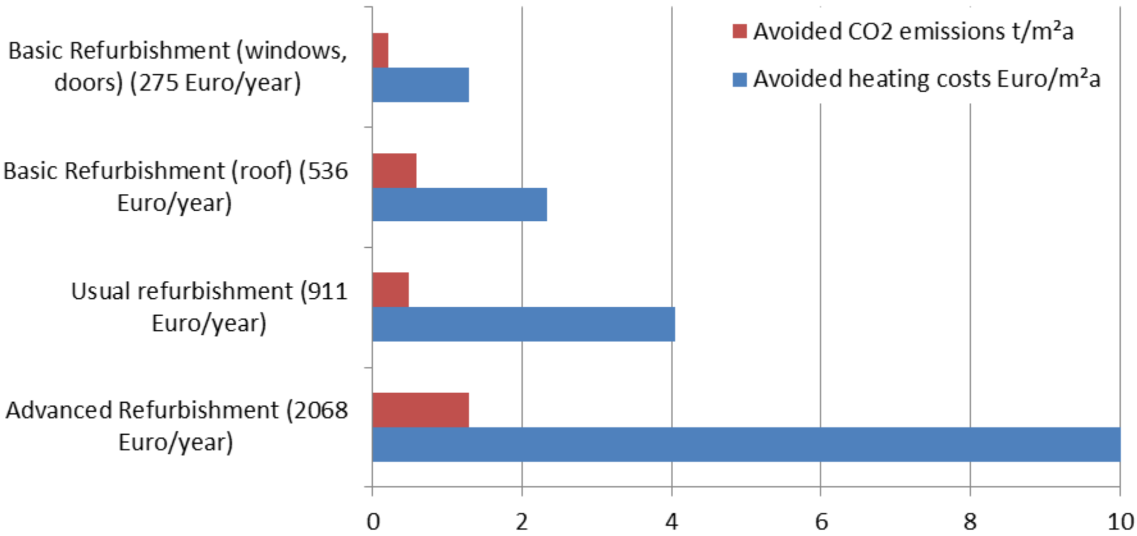
[19] This analyses was made for the Austrian community “Dämmstoff Industrie”




Source: Kommunalkredit, own calculations (Ifip, TU Wien, 2015)

**Figure 12:** Comparison of usual and comprehensive refurbishment action

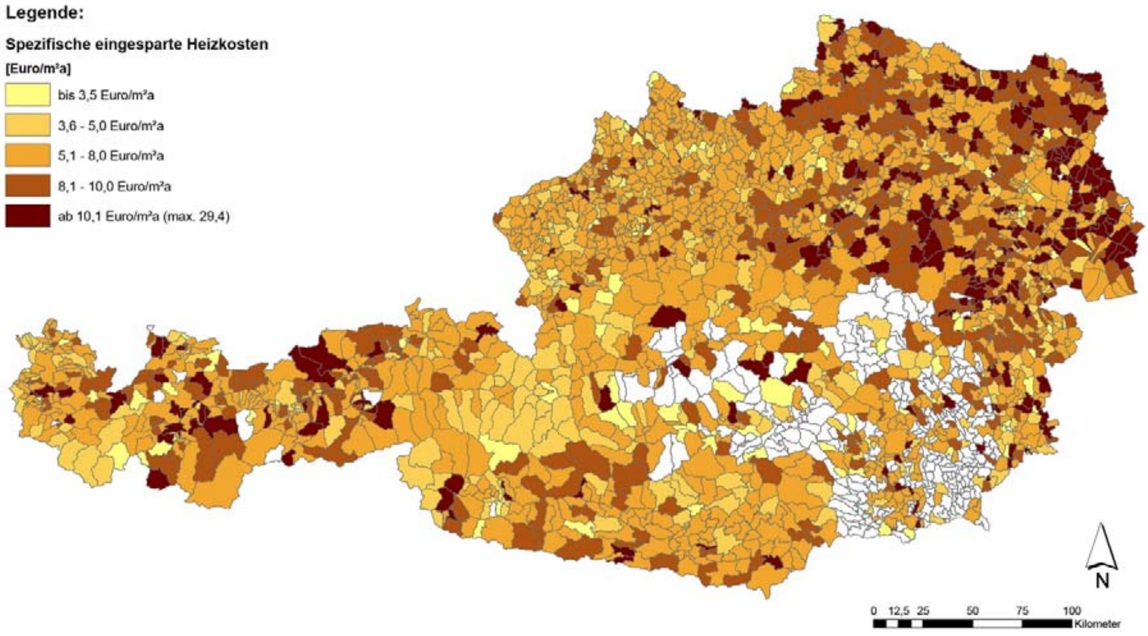
The data of Sanierungsscheck shows that an advanced refurbishment has the best performance for either avoided heating costs and also avoided CO2 emission.




Source: Kommunalkredit, own calculations (Ifip, TU Wien, 2015)

**Figure 13:** Austria: Avoided heating costs and CO2 emissions per year

The average specific avoided heating costs per year were evaluated for each municipality. It shows in which locations and intensity the demand for heating could be reduced. Especially in Easter Austria a lot of heating cost expenses can be saved every year due to refurbishment actions. The best performance (avoided heating costs) could be experienced in Lower Austria (8 Euro/m²a or 1,400 Euro/a), followed by Burgenland (7.21 Euro/m²a or 1,220 Euro/a). In Salzburg only 5 Euro/m²a or 941 Euro/a can be saved. The avoided heating cost for different measure for AT is presented in the figure below.




Source: Kommunalkredit, own calculations (Ifip, TU Wien, 2015)

**Figure 14:** Specific saved heating costs per m² by municipality

## Comparison AT-CZ: Effects of refurbishment actions (Tabula)

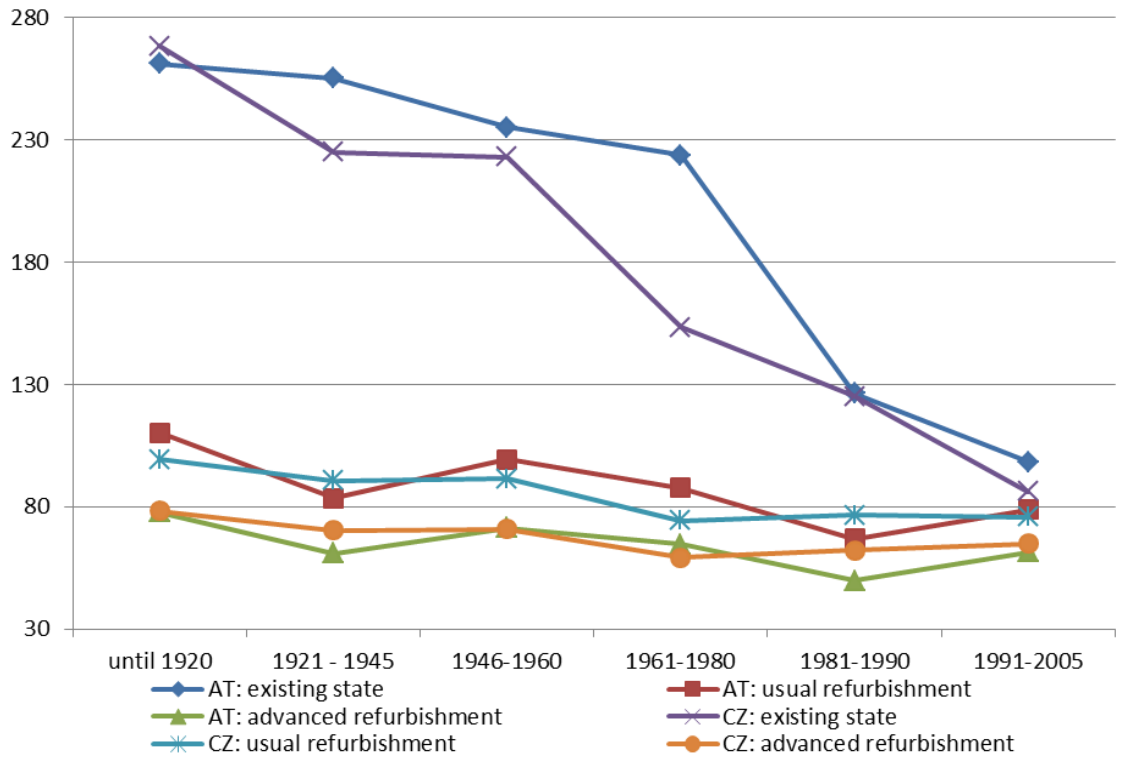
The following table gives an overview of the performances of building retrofit measures for Austria and Czech Republic concerning energy demand for heating, heating costs and CO2-emissions. It can be seen that there are hardly significant differences between the two countries. However the following subchapter tries to explain the most interesting findings.

**Table 7:** Performance of refurbishment action in AT and CZ

| TABULA: Performance of refurbishment actions | | | Apartment Block | Multi Family House | Single Family House | Terraced House | Average all buildings |
|---|---|---|---|---|---|---|---|
| Austria | energy demand (kWh/m²a) | energy need exisitng state | 138,12 | 188,08 | 248,08 | 226,08 | 200,09 |
| | | avoided heating demand usual refurbishment | 71,70 | 105,97 | 145,95 | 125,70 | 112,33 |
| | | avoided heating demand advanced refurbishment | 83,75 | 125,97 | 179,08 | 154,12 | 135,73 |
| | Heating Costs (€/m²a) | heating costs (€/m²a) existing state (AB, MFH: Gas; SFH, TH: Oil) | € 17,05 | € 21,03 | € 26,65 | € 24,73 | € 22,37 |
| | | avoided heating costs usual refurbishment | € 10,75 | € 13,68 | € 18,25 | € 16,45 | € 14,78 |
| | | avoided heating costs advanced refurbishment | € 13,78 | € 17,28 | € 22,52 | € 20,30 | € 18,47 |
| | CO2-emissions (kg/m²a) | existing state | 78,40 | 96,80 | 143,33 | 132,77 | 112,83 |
| | | avoided CO2-emission (kg/m²a) usual | 49,55 | 63,08 | 97,55 | 87,65 | 74,46 |
| | | avoided CO2-emission (kg/m²a) advanced | 64,60 | 80,75 | 122,42 | 110,27 | 94,51 |
| Czech Republic | energy demand (kWh/m²a) | energy need existing state | 139,37 | 170,62 | 236,85 | 174,23 | 180,27 |
| | | avoided heating demand usual refurbishment | 76,80 | 89,07 | 125,63 | 90,83 | 95,58 |
| | | avoided heating demand advanced refurbishment | 87,25 | 106,07 | 149,47 | 107,65 | 112,61 |
| | Heating Costs (€/m²a) | heating costs (€/m²a) existing state (AB, MFH: Gas; SFH, TH: Electric) | € 18,38 | € 20,90 | € 38,87 | € 29,48 | € 26,91 |
| | | avoided heating costs usual refurbishment | € 10,98 | € 12,27 | € 24,78 | € 17,62 | € 16,41 |
| | | avoided heating costs advanced refurbishment | € 13,63 | € 15,35 | € 30,13 | € 22,12 | € 20,31 |
| | CO2-emissions (kg/m²a) | existing state | 83,63 | 95,17 | 156,57 | 116,93 | 136,75 |
| | | avoided CO2-emission (kg/m²a) usual | 32,53 | 38,12 | 62,18 | 51,87 | 57,03 |
| | | avoided CO2-emission (kg/m²a) advanced | 19,97 | 23,58 | 37,68 | 30,38 | 34,03 |

Source: http://episcope.eu; own calculations, 2015

In the following figure for both countries the performance of building retrofit measures is shown. The energy saving potential for the old building stock is enormous, even if only a standard refurbishment is carried out. Generally Czech buildings (especially those built between 1961 and 1980) have a better performance in the existing state, the effects of the retrofitting process seems to be quite similar in the two countries.




Source: http://episcope.eu; own calculations, 2015

**Figure 15:** Performance of buildings[20] and applied refurbishment actions in AT[21] and CZ (kWh/m²a)

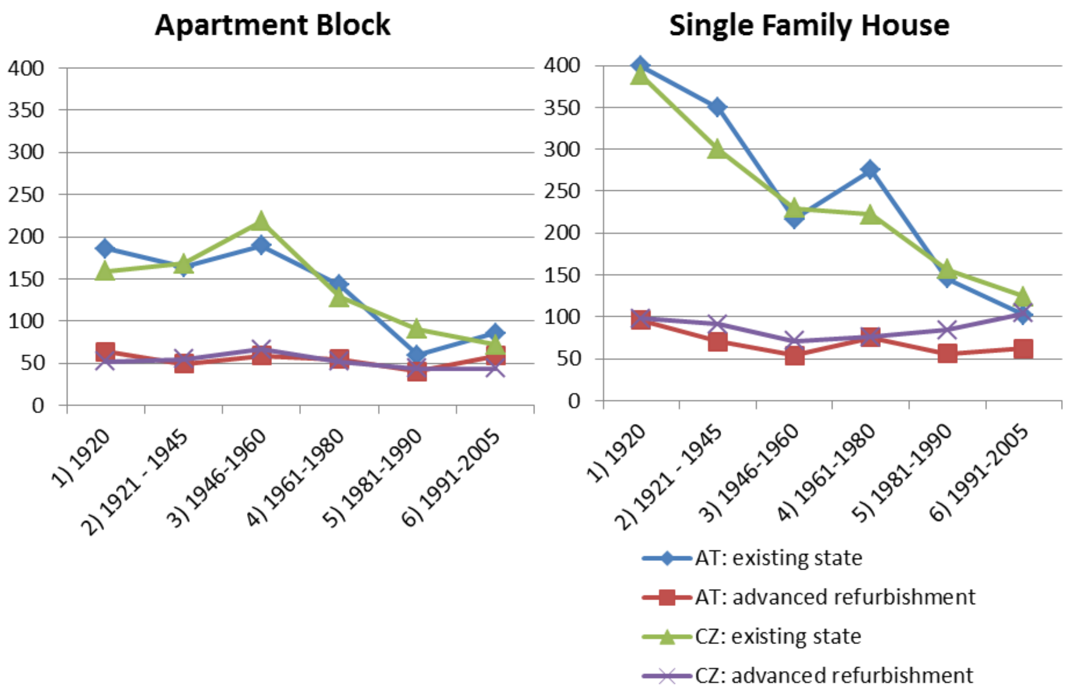
A comparison of single-family houses and apartment blocks shows that the former reach a higher reduction potential of heating demand after a refurbishment measure. It should also be mentioned that apartment blocks are generally very effective per m², as the residential density here is much higher (Figure 16).

If heating costs are considered (Figure 17), a high reduction potential can be experienced for Austrian and Czech buildings built until 1980. After 1980 the avoided heating costs decrease due to better insulation technology in the construction process. A refurbishment of older buildings seems to be very effective. The advanced refurbishment (klima:aktiv) shows a better performance in Austria, in contrast an advanced measure in CZ is quite similar to an Austrian usual refurbishment action. An advanced refurbishment of an apartment block or multi-family house in AT avoids heating costs of 14-17 Euro/m²a, in CZ it is just 13-15 Euro/m²a.

A comparison of heating costs for gas central heating (high efficiency) and district heating after an advanced refurbishment (Figure 18) shows a price advantage for high efficient gas central heating (lowest heating costs) in Austria. Czech gas central heatings approach the price range of district heating. The higher prices for district heating can be explained due to higher fixed costs (infrastructure supply) as this system is rather newer than the existing gas infrastructure which is already depreciated.

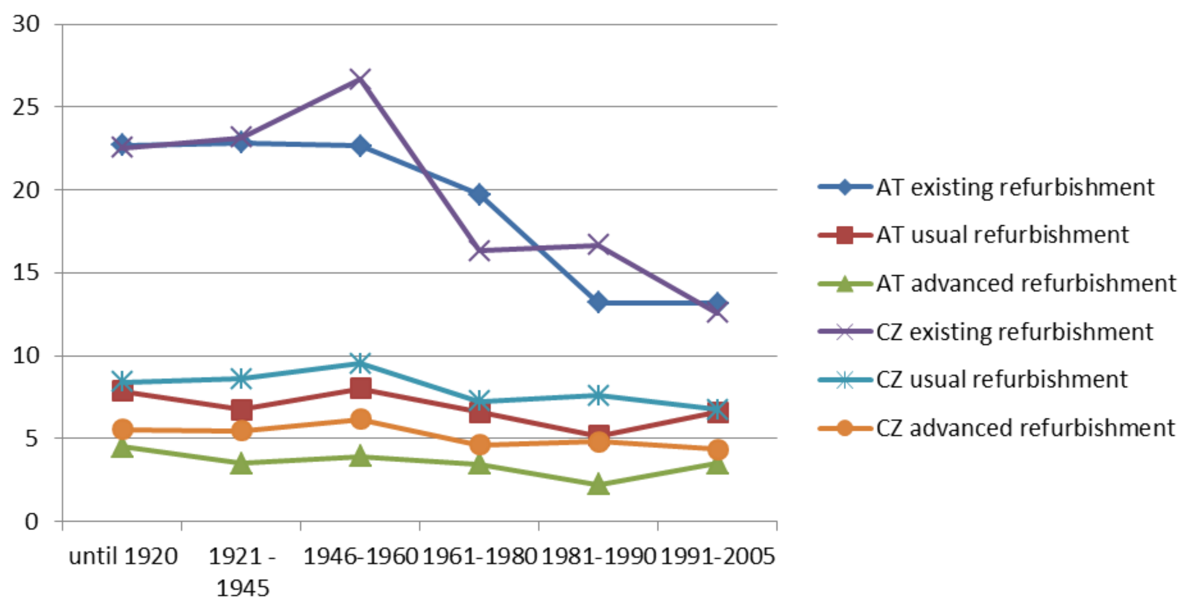
[20] Average for all buildings

[21] In Austria, the advanced refurbishment is a klima:aktiv standard



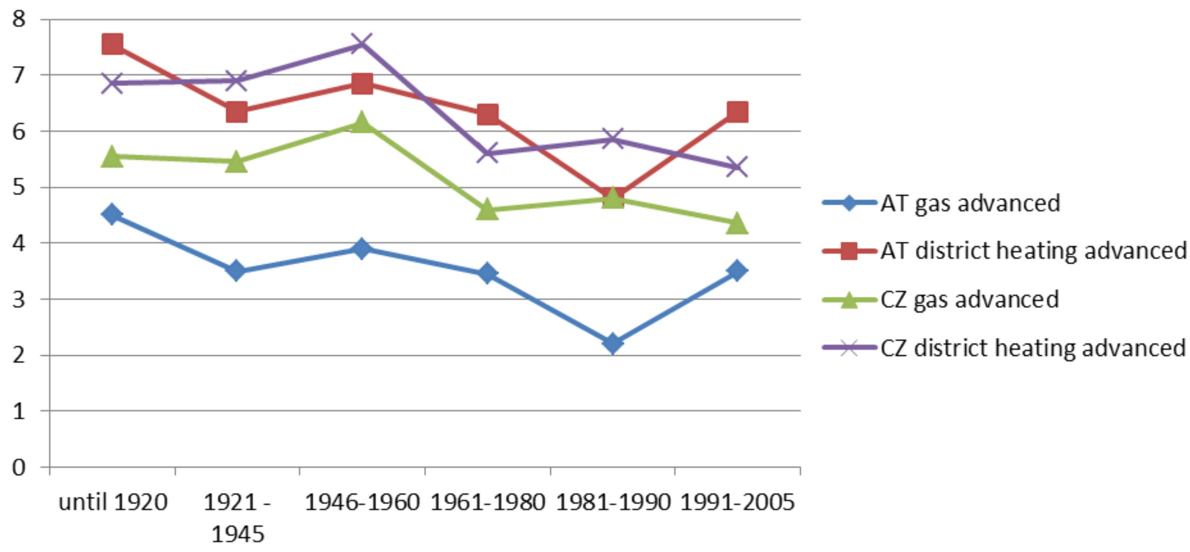

Source: [http://episcope.eu](http://episcope.eu); own calculations, 2015

**Figure 16:** Refurbishment actions in AT and CZ: Single-family hosue versus apartment block (heating demand kWh/m²a)




Source: [http://episcope.eu](http://episcope.eu); own calculations, 2015

**Figure 17:** Heating costs (Euro/m²a) for AT and CZ apartment blocks (AB) and multi-family houses (MFH) (gas heating)




Source: http://episcope.eu; own calculations, 2015

**Figure 18:** Heating costs after advanced refurbishment gas central heating and district heating (AB, MFH)

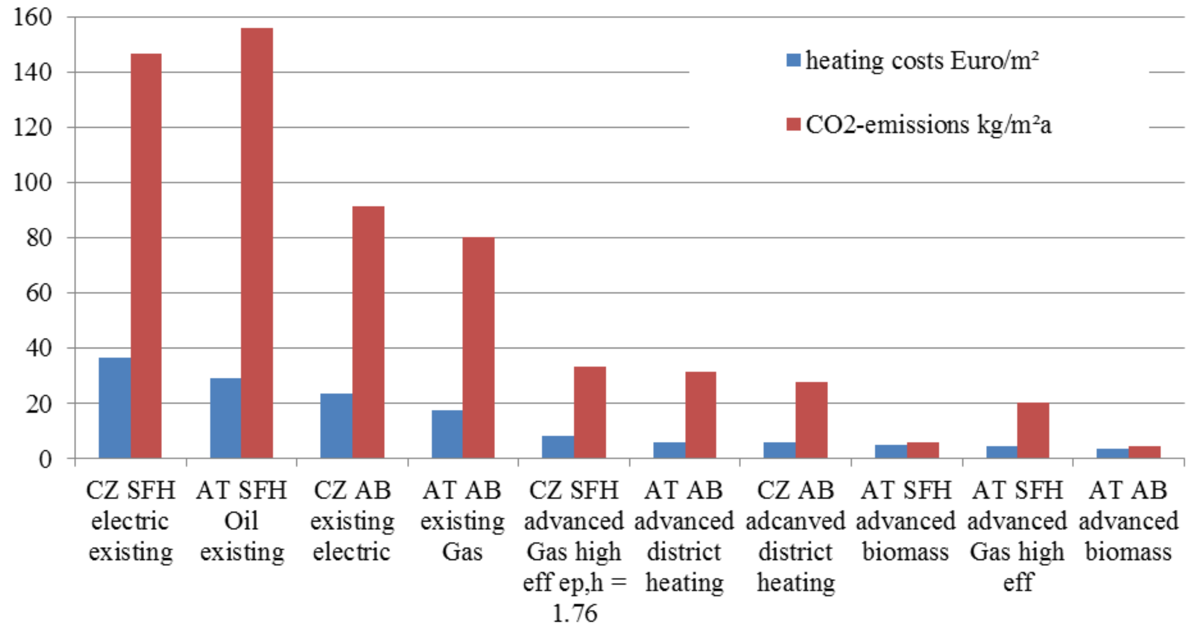
Avoided heating costs and CO2-emissions due to refurbishment actions – selected cases:

The effect of thermal-energetic building modernization was analysed for typical cases in Austria and Czech Republic. The goal was to compare the different heating systems and its influence on heating costs and CO2-emission. The selection of the heating system contributes to the amount of CO2 emitted not insignificantly. The following systems and building types have been considered:

- Single-family houses (SFH) and apartment blocks (AB)
- Heating systems: electric (+night storage), oil, gas central heating, district heating, biomass

Results:

- Fossil-fuel based heating systems have the most CO2 emissions and heating costs (first 4 existing states in AT and CZ), although apartment blocks have a better performance.
- An advanced refurbishment with district heating lowers the heating costs, but not CO2 emissions → gas central heating systems have the same range of emissions
- Biomass represents a good performance for SFH and AB in an advanced refurbishment: the lowest heating costs per m² and year as well as the lowest CO2 emissions
- The typical gas central heating system in AT seems to be more efficient or cheaper than in CZ




Source: http://episcope.eu; own calculations, 2015

**Figure 19:** Heating costs and CO2-emissions of different refurbishment actions and heating systems

## Building-Retrofit-Policies

The goal of this research is to get an overview of all relevant building retrofit policies available in Austria, Czech Republic and the European Union and its implementation in national law. As the EU has a large influence on the Member States' energy-efficiency politics, the connection between EU and the selected countries is considered. The policy overview consists of policies that cover the general goal to reduce the consumption of energy, increase energy-efficiency and the reduction of greenhouse gas emissions as well in many sectors to reach future climate and energy goals. Only the most relevant policies that touch the energy efficiency of buildings will be explained in the following subchapters.

### European Union Policies

2020 Climate and Energy Package and targets for 2030:

It is a set of binding legislation to ensure that the EU meets their climate and energy targets for 2020. Known as the 20-20-20 targets, three key objectives are followed: GHG emissions reduced by 20%, share of RES and energy efficiency increased by 20%. This and other directives as well as their resultant national legislation should increase the motivation to reduce energy consumption and its associated negative environmental impacts.

The Green Paper *"framework on climate and energy efficiency for 2030"* is a further agreement of all EU leaders to reduce greenhouse gas emissions by 40% to 1990 with the aim to make the EU more competitive, secure and sustainable. The share of RES and energy efficiency should be increased to at least 27% and the emission trading system reformed. Every country has defined targets. CZ for instance did not specify the targets[13, p. 3] (status: March 2014).

Not to forget is the international agreement *"Kyoto Protocol"* since 1992 of the United Nations to change the high global warming potential to reduce greenhouse gas emissions. It influenced the climate and energy debate of many countries as well as EU Member States towards more sustainability.

Energy Performance of Buildings Directive EPBD:

The main basis for buildings concerning energy efficiency and greenhouse gas emission reduction on buildings is the EPBD, the *"Energy Performance of Buildings directive" (2010/31/EU).* It is a revision of the EU-directive 2002/91/EU that deals with the performance of buildings. In 2002 national standards and CO2 emissions had to be set for new buildings and buildings that were renovated above 1000 m² (in AT). Additionally energy certificates have to be issued for new or renovated buildings. The revision in 2010 brought new changes:

- Mandatory evaluation of the use of renewables for all buildings
- Removed the 1000 m² threshold
- Buildings (public with 2018; all other with 2020) have to be "nearly zero energy" buildings[22]
- Energy certificate for all buildings at construction, selling or renting
- Member States have to set minimum energy performance requirements for buildings. Cost optimal levels over the whole lifetime of the building was introduced (energy and cost efficiency) and member states are required to establish a financial support for energy saving investments

The energy performance certificate: It has a common base in all EU countries to increase transparency of the energy used in a specific building. Inputs are the primary energy consumption of the building taking into account energy consumption by space heating (depending on insulation, ventilation, heating system), hot water and auxiliary products for ventilation and cooling. A simple universal indicator is used to show energy consumption, either calculated or measured. The index reaches from A++ (efficient buildings) to G (highly inefficient buildings).

Energy Efficiency Directive (2012/27/EU):

It is a revision of the *"Energy End-Use Efficiency and Energy Service Directive" (2006/32/EG)* which originally indicated energy saving targets. **The Energy Efficiency Directive 2012/27/EU and the EPBD are the EU's main legislation when it comes to reducing the energy consumption of buildings**. It establishes a set of binding measures to reach the EU 20% energy efficiency target by 2020 which are introduced in the *"2020 Climate and Energy Package" (406/2009/EG).* The main focus is on the renovation of existing buildings and the improvement of energy savings and efficiency. "*This includes making central government buildings more energy efficient and requiring EU countries to establish national plans for renovating overall building stock.*[14]" Member States have to draw up strategies to reach the goals *in national building renovation strategies*. This are part of the *"National Energy Efficiency Actions Plans"* that provide[14]:

- overview of the country's national building stock
- identify key policies that the country intends to use to stimulate renovations
- provide an estimate of the expected energy savings that will result from renovations

[22] Definition done by member states

Renewables Directive (2009/28/EG):

It is a common framework for the use and promotion of renewable energy sources and to fulfil at least 20% of energy needs with renewables by 2020[23]. This is achieved by national targets called "national action plans and progress reports".

The *"Cogeneration Directive" (2004/8/EC)* from 2004 requires for each EU-country an assessment of the national potential of cogeneration and district heating/cooling until end of 2015. It is important for the use of energy for heating and usage of heating systems itself. For refurbishments a cost-benefit analysis should be conducted on the potential for using cogeneration.

Policies for products used in the residential, tertiary and industrial sectors:

For products the *"Energy Consumption Labelling Scheme" (2010/30/EU)*[24] was adopted in 2010. It is important to achieve a decrease in the energy consume of products, which is done by energy labels. The use of F-gas in air conditioning or refrigeration is regulated in the *"F-Gas Regulation 2012"*. The use of energy-related products accounts for a large proportion of the energy consumption in the EU. Therefore the *"Ecodesign Directive" (2009/125/EC)*[25] provides consistent rules for improving the environmental performance of energy related products (ERPs). It is for products that use, transfer or generate energy and those which do not use energy but have an impact on energy consumption. A further regulation is the *"Construction Products Regulation" (EU305/2011)* that should ensure reliable information on construction products in relation to their performances by offering uniform assessment methods of the performance of these production products.

[23] It was influenced by the 2020 Climate and Energy Package (20-20-20 goals)

[24] Revision of 92/75/EC

[25] 2009 it was extended to all energy-related products

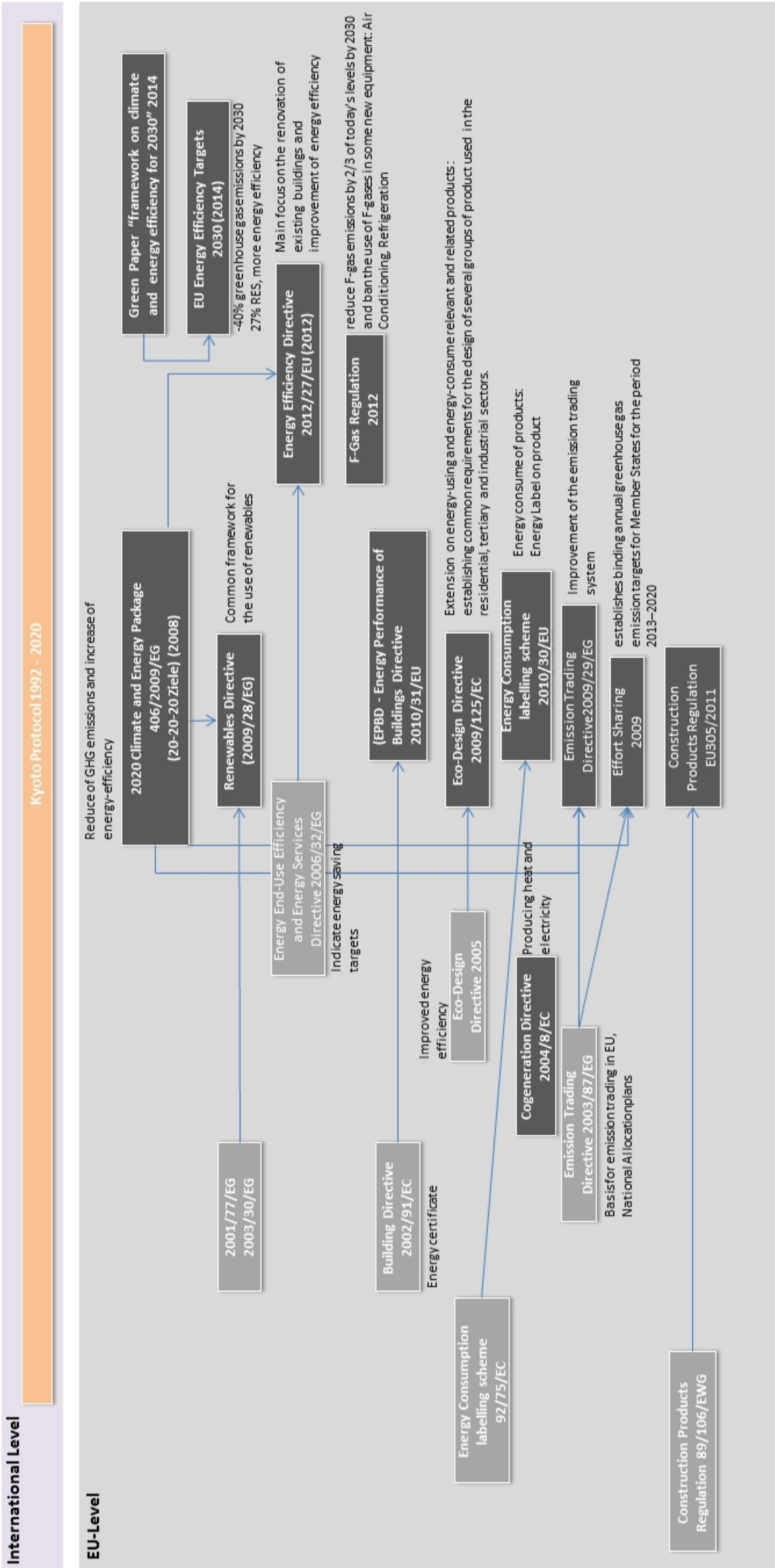



**Figure 20:** Policy overview EU-level (Sources: [9], [13], [15]–[17])

## Austria

Austria has agreed on the 20-20-20 targets and producing 34% of its energy from RES where also the measures in the building stock are relevant to be treated. In Austria the provinces have been bound to deal with the building sector. 9 different building codes exist that have been harmonized in 2008 by the Institut of Building Technology (OIB) founded by the provinces[9]. The implantation of the rules were done by concrete technical requirements (energy demand for instance) that have been developed by the OIB. There is also a compatibility of the regulation with the EU regulations[26].

The legislation on buildings' energy efficiency was mostly influenced by the EU and the Kyoto targets. In 2005 Austria implemented the first Building Directive of the EU, the *"Building Directive 2002/91/EC"* to meet the targets of emissions set in the *Kyoto Protocol*[27].

<u>Implementation of the EPBD in Austria:</u>

As one of the most important basis for energy efficiency in building, the EPBD was implemented in Austria in 2012 with the *"Energieausweis-Vorlage-Gesetz (EAVG 2012)"* and the *"OIB Regulation 6 Energieeinsparung und Wärmeschutz"* in 2011.

**OIB Regulation 6 (regional level):** done by the OIB (as mentioned before) and revisioned in March 2015, this regulation also includes "*national building regulations (Ö-Normen)"* by the Austrian Standard Institute (as part of the International Standards Organisation ISO) that develops and manages about 24,000 standards and rules for Austria. Relevant Ö-Normen to energy efficiency of buildings are Önorm B8110 (thermal protection in building construction) and H5058 (energy performance of buildings).

The OIB regulates:

- Thresholds for primary energy demand of new and renovated buildings as well as CO2 emissions
- Calculation programmes
- Energetic and emission classification of buildings in the energy certificate (table below)
- Energy savings and heat insulation
- Requirements for certification of energy certificate

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[26] 2010/31/EU or 89/106 EEC for instance

[27] Agrement to reduce emissions by 5% of 1990 level and reduce ist gases by 13% between 2008 and 2012, which targets were not achieved

**Table 8:** Classification of buildings depending on energy demand

| Klasse | $HWB_{Ref,SK}$ [kWh/m²a] | $PEB_{SK}$ [kWh/m²a] | $CO2_{SK}$ [kg/m²a] | $f_{GEE}$ [-] |
|---|---|---|---|---|
| A++ | 10 | 60 | 8 | 0,55 |
| A+ | 15 | 70 | 10 | 0,70 |
| A | 25 | 80 | 15 | 0,85 |
| B | 50 | 160 | 30 | 1,00 |
| C | 100 | 220 | 40 | 1,75 |
| D | 150 | 280 | 50 | 2,50 |
| E | 200 | 340 | 60 | 3,25 |
| F | 250 | 400 | 70 | 4,00 |
| G | > 250 | > 400 | > 70 | > 4,00 |

Source: OIB regulation 6 [12], 2015

**Energieausweis-Vorlage-Gesetz (EAVG 2012) (national level):** On federal level it regulates when an energy certificate has to be issued. It also gives references to the provinces. In Austria a certificate has to be issued when a building is built, renovated, rent or sold. Its general aim is to improve energy efficiency of buildings. Together with the OIB regulation and Ö-Normen it creates a strong framework for energy efficiency for buildings [18].

<u>Implementation of the Energy Efficiency Directive (EED) 2012/27/EU:</u>

As second most important basis for energy efficiency in the EU, the EED was implemented in 2014 with the *"Energieeffizienzgesetz"* on national level to set energy efficiency measures according to 2012/27/EU. It has also influence on the regional level (OIB Richtlinie 6). It has the target to increase energy efficiency and RES by 20%, guarantee energy security, reduction of GHG emissions.

Before 2012 the *"Energy-End-Use Efficiency and Energy Service Directive" (2006/32/EG)* tried to indicate energy saving targets, incentives as well as frameworks to minimize market barriers preventing efficient use of energy in the EU. The purpose of this directive was to make the end use of energy more economic and efficient. Member states had to adopt and achieve indicative energy saving targets of 9% by 2016 in a *"National Efficiency Action Plan (NEEAP)"*. Austria created its first *"NEEAP 1"* in 2007 [19]. Until 30.6.2011 the member states had to submit a second action plan. The *"NEEAP 2"* includes all requested contents and describes measures to implement the goals in Austria[20].

<u>Other directives and laws on national level:</u>

The *"Austrian Energy Strategy (2009)"* is an answer to the 2020 Climate and Energy Package by the EU and concentrates on the security of energy supply, energy efficiency and renewable energy sources to allow the implementation of the 2020 goals.

The *"law for expansion of district heating WKLG, BGBI.I No113/2008"* and the *"CHP-law 2009"* try to promote efficient energy supply (district heating/cooling infrastructure and CHP techniques) of more renewable energy sources.

The EU Eco-Design directive 2005 was conducted 2007 with the *"Ökodesign Verordnung"* in 2007. Besides the *"klima:aktiv initiative"* by the BMLFUW which started in 2004 should contribute to more protection of the climate as well as market launch of more sustainable technologies and is part of the Austrian *"Klimastrategie (2007)"* which aims to reduce GHG emissions by 13% from 2008-2012 referenced to the year 1990.

The *“Klimaschutzgesetz (2011)”* is an update on how to reach Kyoto targets. It defines maximum amounts of emissions that can be emitted between 2008-2012 and 2013-2020 and measures for climate protection. It is an important part for Austrian’s politics on climate issues.

There is also the *“Nationaler Aktionsplan (NAP)”* from 2010 as an answer to the *“Renewables Directive” (2009/28/EG).* It deals with the implementation of RES in Austria and explains how this is impossible. Austria has the goal reach a share of 34% renewable energy sources. The Czech Republic only has a target of 13% set.

<u>Regional level:</u>

Between the federal state and the provinces the §15 B-VG (Bundesverfassungsgesetz) agreement called Bund-Länder-Vereinbarungen exists. It says that the federal state and provinces can conclude agreements on some issues[21]. In 2009, an agreements according to §15 B-VG was conducted to decrease greenhouse gas emissions in the building sector by fostering building modernization and new low-energy buildings. Additionally a funding scheme (Wohnbauförderungen) should be established. The provinces have to implement these agreements which are done in the harmonized building codes in 2008 (energy certificate, use of energy efficiency and sustainable energy systems, etc.) and the OIB by the *“OIB Richtlinie revision 6”* in 2011.

<u>Financial funding schemes in Austria:</u>

Two of the most important funding schemes in Austria concerning buildings are the regional *“Wohnbauförderung”* and the national *“Sanierungsscheck”.*

The “Wohnbauförderung” is a strong funding scheme for energy efficient measures and use of renewable energy carriers. The budget for building retrofit stagnates since 10 years at a share of 25%, with a total budget of 2.4 billion Euro. Since 2006 the minimum thresholds for the space heating demand for building retrofit are fixed in the §15 B-VG agreements and 2012 strengthened. The main focus of the Wohnbauförderung is climate protection in new or thermal-energetic modernized and renovated buildings. The tool could reach an improvement of heating demand in the retrofit process from 67 kWh/m²a in 2006 to 48.8 kWh/m²a in 2011. For new buildings it changed from 42 to 28.8 kWh/m²a.

The *“Thermische Sanierung”* or *“Sanierungsscheck”* is a program for thermal renovation of the housing building stock older than 20 years. It was first time introduced in 2009. The budget for 2015, financed by the federal state, is 80 million Euro. With 22.6.2015 there are only 22 million Euros left. This subsidy is well accepted and used by people. In 2013 the funding was exhausted after 10 minutes. Funded are measures like the insulation of exterior walls, windows, change of the heating system, insulation of the roof or comprehensive thermal-energetic refurbishments. There is a bonus if renewable windows are used for instance. The maximum subsidy is 30% of the subsidized costs or 6,000 Euro and 2,000 Euro for the change of the heating system. The requirements differ from year to year. One major disadvantage is that the heating demand reduction is only calculated before the refurbishment action and not measured afterwards.

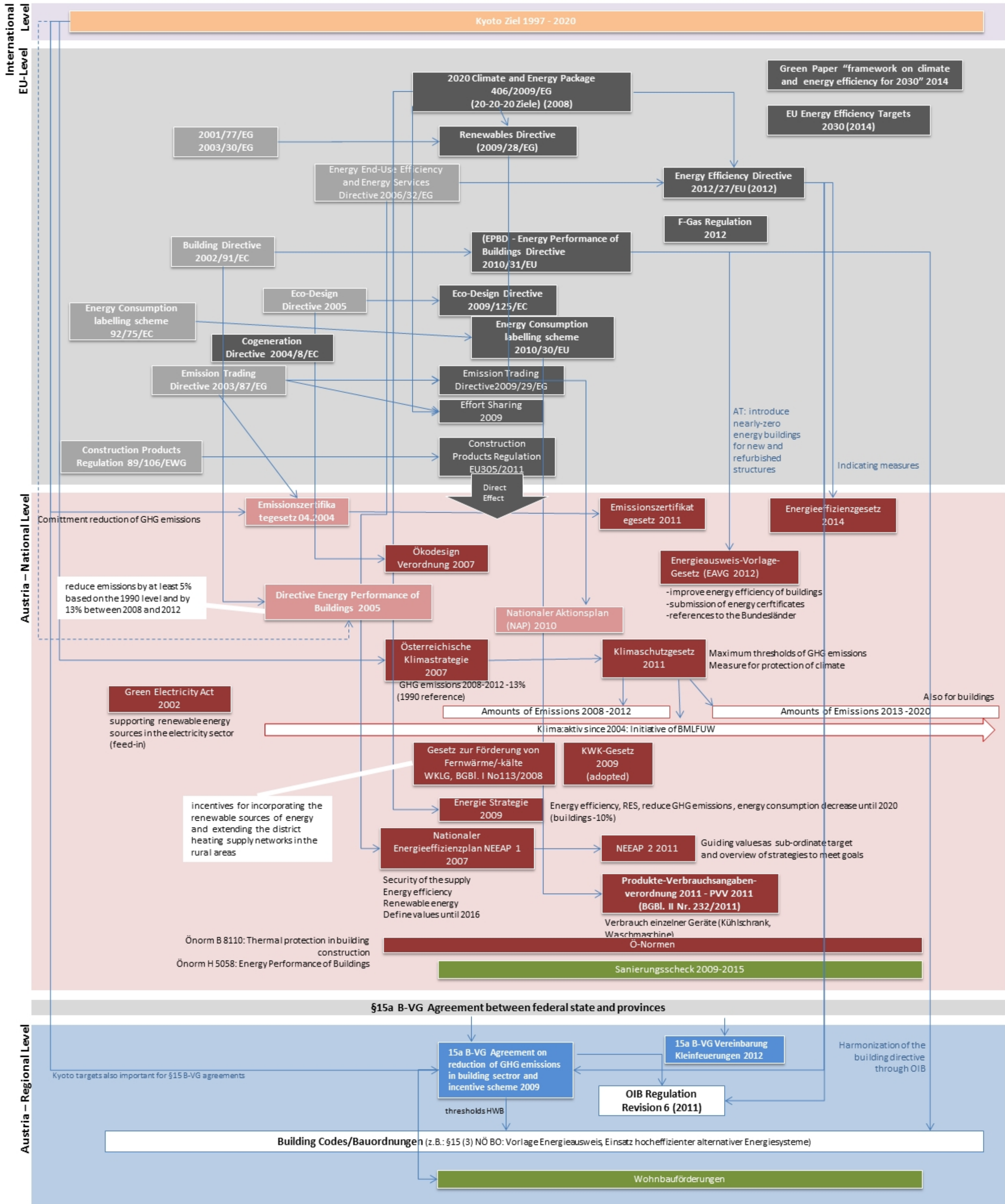


**Figure 21:** Policy Overview Austria and EU level

### Czech Republic

First there was the *Act no. 406/2000* Coll. of Energy Management, which became on 25th of October 2000. This Act has been already amended many three times. Essential subject of the Act:

- some measures to increase the efficiency of energy use and obligations of natural and legal persons in energy management
- the rules for the creation of the State Energy Conception (SEK), Territorial energy concepts and the State program to support energy savings and use of renewable and secondary energy sources
- requirements for the eco-design related with the energy utilization
- requirements for the marketing of energy and other essential resources by energy labelling products
- requirements for information and education in the field of energy savings and use of renewable and alternative energy sources [22]

*The SEK* provides reliable, safe and environmentally friendly energy supply for the needs of the population and the economy of the Czech Republic. The State Energy Conception expressing the government's objectives in energy management. It's the strategic goals are safety, competitiveness, sustainability.  Last actualization has been in 2010 and it's valid to 2030 [13].

Main named goals:

- Removing the dependency on imported energy -> reach 80% domestic sources of energy by 2040
- Nuclear energy is given a preferential role (completion of units Temelin and Dukovany)
- Focus on the mix of different energy sources by 2040.
- The government assumption -> renewable energy source will become fully economically independent and state support will be gradually withdrawn.
- Smart energy network -> strengthen the distribution and off-grid systems will be also supported in case of any unforeseen circumstances.
- Retrofit building policy is built on passive energy building houses -> they become as a new main stream in construction type after 2020.

*No. 318/2012 Coll.* is the latest amendment of the Act. Amendment has been accepted on 3rd of November 2013 and became valid on 1.1. 2013. Validation to 30th of June 2015.

*No. 318/2012 Coll.* comes with changes ordered the EU directives The Energy Performance of Buildings Directive 2010/31/EU. The directive takes care, beside others, about economy and the main change in law is „the optimum cost“. It compares the range of consumption and saving of energy. The most important change for public is the Energy Performance Certificate of buildings.

Main paragraphs of the amended law related to buildings are §7 and §7a. The first one gives rules how to decrease energy performance of buildings and the second one gives instruction about the Energy Performance Certificate (EPC).

Instruction which are related with EPC:

- 1.1.2013 all new buildings and reconstructed building (with greater reconstruction of 25% of total area of building envelope) have to have EPC
- 1.1.2013 buildings which are for sale or rent ot it's integrated part (flat)
- 1.7.2013 building utilized by public authorities (such as municipal office, police, fire department, court etc.) with total energy related area greater then 500m2 have to have EPC
- 1.1.2015 apartment buildings, office buildings with total energy related area greater than 1500 m² have to have EPC
- 1.7.2015 building utilized by public authorities with total energy related area greater than 250 m² have to have EPC
- 1.1.2016 in case of renting the integrated part of the building, it's applies also for condominium
- 1.1.2017 apartment buildings, office buildings with total energy related area greater than 1000 m² have to have EPC
- 1.1.2019 apartment buildings, office buildings with total energy related area less than 1000m² have to have EPC

There are also some excuses of some building which do not have to have EPC e.g. cultural heritage, sacral building or recreation buildings (cottage) [23].

There are two important decree which are important to mention:

*No. 480/2012* coll. which is related to the Act of Energy Management. This dercee amended sector of the Energy Audit and Energy Review, exactly specifies rules of paragraphs §9 and §9a of the *No. 318/2012* Coll. Become valid on 1.1.2013.

- the obligation to prepare an energy audit arises when average annual consumption of energy for the last two years higher than the set limit regulation or in the case provability unavailability of required EPB due to technical or economic unsuitability of larger completed buildings

- the obligation do not arise when it comes into energy management, if it‘s a device for the production, transmission and distribution of electricity and equipment for the production and distribution of thermal energy or if it's a completed building, which specific heat consumption for heating conforms to the requirements [24].

The second decree is *No. 78/2013* coll. is especially important in retrofit building policy. It's regulate an energy performance of building, it's gives patterns of the performance optimum of almost zero energy consumption of building, there are also methods of counting EPB, measures how to get EPB, pattern of EPC and other rules related to it [25].

The latest amendment of the *Act no. 406/2000 Coll*. is *No. 103/2015 Coll.* Which was accepted on 10th of April 2015 and it will be valid since 1st of July 2015.

The second important Act related into retrofit building policy is the no. *165/2012 Coll*. This law regulate the content and the creation of a *NAP CZ 2010 – 2020* for RES . Essential subject of the Act:

- support for electricity, heat and biomethane from RES, secondary sources of energy, high-efficiency combined heat and power and distributed generation of electricity

- conditions for origin of energy from renewable sources
- financing aid to cover costs associated with supporting electricity
- levy on electricity from solar radiation [26]

*The National Action Plan for Renewable Energy Sources (NAP CZ 2010 -2020)* - was approved on 25th of August 2010. This document is the fundamental strategic document in the field of RES. It’s based on the Member State's obligation as defined in the Directive of the European Parliament and the Council no. 2009/28 / EC. It is a binding target share of energy from renewable sources in gross final consumption of energy in the CZ amounted to 13% in 2020, which includes a binding target share of energy from renewable sources in all modes of transport on gross final consumption of energy in transport in the CZ by 10% in 2020 reach a 14% share of energy from renewable sources in gross final energy consumption and a 10.8% share of energy from renewable sources in gross final consumption in transport [27].

*NAPEE III. CZ* [27] is the national action plan energy efficiency, approved on 22nd of November 2014 and valid from 2014 to 2020. This AP comes from EU Energy Efficiency directive 2012/27/EC. The document sets national targets of the Czech Republic and outlines the measures in individual sectors. There are measures for buildings, industry, transport, or in transmission and distribution systems. Furthermore, the methodology for calculating energy savings. Included in annexes to document also report on the progress made and the Strategy building renovation.

*Green saving program ran 2009 – 2013* [28]: This project was run and financially subsidized by Ministry of the Environment. Financially support was mainly by sold so called emission credits under the Kyoto Protocol on reducing greenhouse gas emissions. Further available resources fund to strengthen program resources was the account to support the collection and processing of car wrecks. Special fund for energy efficiency in public buildings was from the government budget reserve corresponds to the proceeds from the auctioning of allowances remaining in the reserve for new entrants.

This program was focuses on support for the installation of heating sources, using renewable energy sources, but also investment in energy savings in renovations (such as insulation, replacement heating for low-emission biomass, solar thermal collectors etc.) and new buildings (focused on construction in the passive energy standard) such as house, apartment building, office building, public building etc. Ask for support could everyone.

What’s the assumption, what does it should bring:

- reducing CO2 emissions by 1.1 mil. tonnes, 1% of all CZ emissions
- saving heating energy of 6.3 PJ; saving the cost of household heating
- create or preserve 30,000 jobs
- improving housing conditions for 250,000 households that receive support
- increase heat production from renewable sources by 3.7 PJ
- particulate pollution reduction by 2.2 mil. Kg

Period has expired by 31.12.2013. Nowadays is analyzed the success of the GSP .

*New Green Saving – 2013 – 2020* is new re-open period of the program and it has the same progression [29].

*EFFECT 2013* is an energy efficiency programme. It is run by the Ministry of Industry and Trade, pursuant to Act No. 406/2000 Coll.

- It supports small investment projects focussed on achieving energy savings and provides for financing in Prague, mainly directed at smaller and medium sized companies and local councils.

Four the most used assessment of building energy performance in CZ. The methodology for evaluating the energy conumption of building is not uniform and unambiguous.

*CSN 73 0540* defines low energy, passive house and zero energy house

TNI 73 0329 – asses. for houses TNI 73 0330 asses. for apartment buildings. Unified approach for the assessment and classification of buildings with low energy demand. TNI assesses the primary energy for the operation of a passive house from non-renewable resources. Electrical energy for the technology must not exceed

60 kWh / (m2.a). It is used for the assessment of buildings in the grant program Green Savings SEF.

EPC - mentioned above, according to no. 78/2013 coll.

PHPP _ Passive house planning package is an instrument to optimaized energy performance of passive houses. According to PHPP there are some criteria which the passive house must fulfil [13], [30].

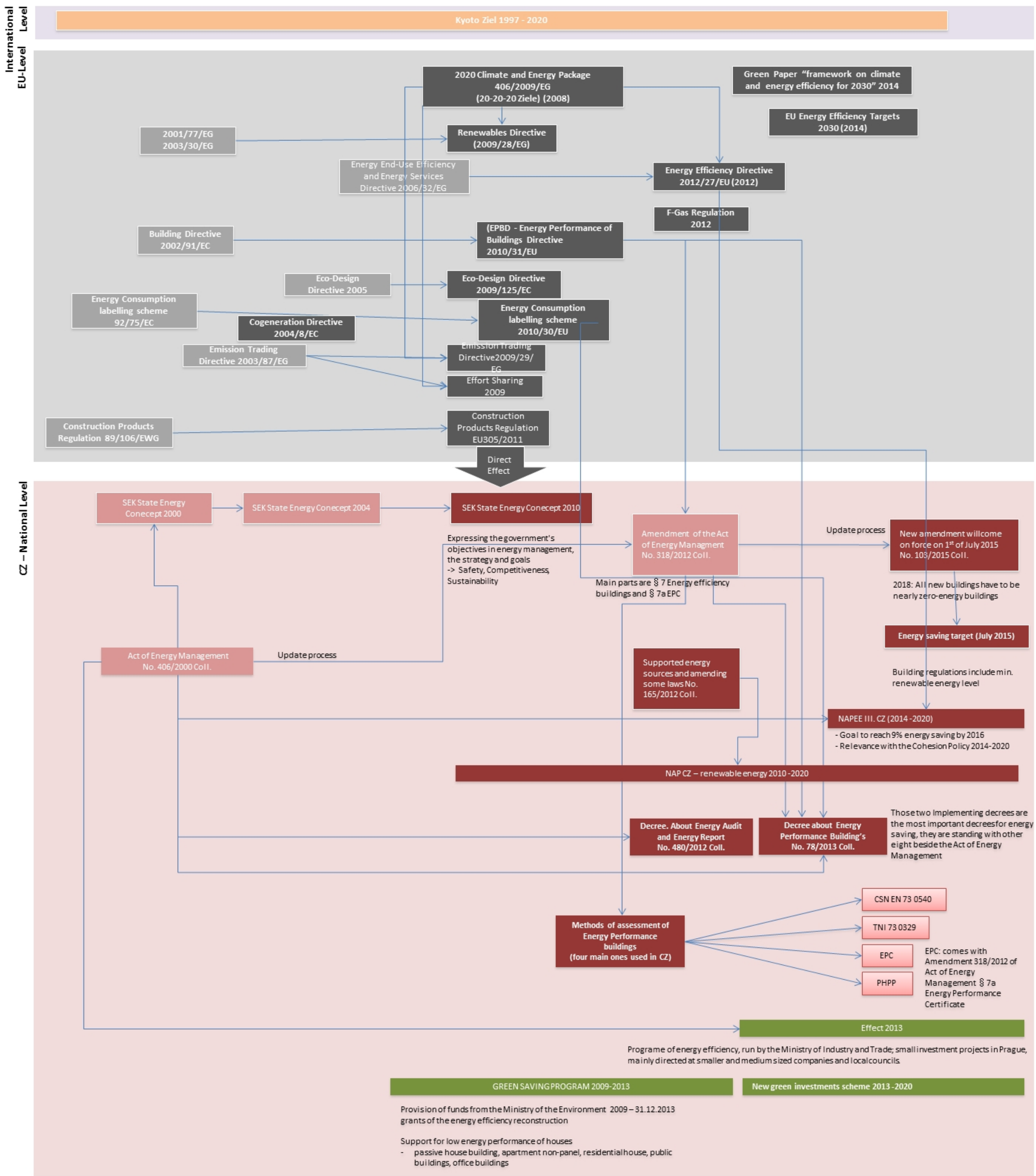


**Figure 22:** Policy Overview CZ and EU level

## CONCLUSIONS

Effects of building refurbishments:

There is shown a significant correlation between CO2 emissions and the related energy consumption by peoples' activities. The building sector currently has a high share if energy consumption is considered. Thermal-energetic building modernizations can firstly be undertaken with a renovation that has to be done anyway and secondly reduce the energy demand. This is important for the large share of single-family houses in Austria and CZ. With increasing number of apartment blocks the legislation between tenants and landlords should be established and considered in a further detail. Often the landlord or majority of an apartment dwelling can decide for a building refurbishment. As the EU legislation for reaching future sustainability targets is still widely developed, a deeper look should be taken on minimizing barriers that prevent sustainable investments. This can be a further key of concentration in the EU.

In every country the specific building types show different heating demands. So there can't be a solution for equal building retrofit measures for all buildings type in the EU. The analyses between Austria and Czech Republic showed that the heating demand generally improves with younger buildings (better and energy efficient technology available). The need to retrofit a building differs depending on the age period a building was built and the type of building itself. Time can't be only seen as indicator for the improvement of thermal-energetic building performance. Buildings built before 1920 have a better performance than buildings built after World War 2 for instance. Newer buildings (from 1980) in Austria seem to have generally a better performance in Austria that in Czech Republic. This might result in better technology available for building construction and more financial possibilities as the Austrian economy and income is much better/higher that in CZ. The analyses show a more energy and cost saving potential for buildings that are refurbished in CZ.

The best performance in the existing state show apartment blocks compared to all other buildings. Existing[28] single-family houses have the worst performance (highest energy demand and CO2 emissions). The standards for new buildings seem to be more restrictive towards more energy-efficiency in AT than in CZ. In AT the OIB 6 rule determines strict guidelines for energy demand for new buildings very strictly.

One important benefit of building modernizations is the high amount of energy costs (10-20 Euro/m² per year) that can be saved and used for other investments in the Austrian or Czech economy and not directly transferred to the supplier of fossil fuels abroad. A comprehensive refurbishment can save about 50 to 70% of demand for heating, in combination with a renewable heating system a lot of CO2 emissions can be avoided and efficiency of the whole system increased[29]. It is interesting that the stated advanced refurbishment in the analyses shows a better performance in AT than in CZ. This might be due to a better availability of insulation material or knowhow. The selection of the heating system also influences the performance. While district heating is still very expensive and

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[28] Existing should mean that the buildings are not thermal-energetically refurbished.

[29] New heating systems show a very good effectiveness

gas cheap (difference in AT is about 3 Euro/m²a) in Austria[30], in CZ it is reversed. The best performance shows biomass heating with less CO2 emissions and heating costs.

<u>Building-Retrofit-Policies:</u>

On EU-level there are a lot of policies available that deal with sustainability, reduction of greenhouse gases and energy efficiency. Buildings are often mentioned as they have a high reduction potential and possibility to save a lot of energy. Technology for energy efficient measures on buildings is competitive and a strong subsidy scheme is established. The targets we want to reach are very ambitious but probably able to be reach with building retrofit measures. In the sector space heating a large reduction of CO2 emissions could be observed in the last 20 years, whereas transportation increased massively. The implementation of retrofitting rules and thresholds for every member states makes sense, because the building stock and most efficient ways to reach the common targets vary in each country. It is also important that renewable and nearly carbon-free technological systems (e.g.: heating or cooling) are more promoted to be used. A gas heating system is still very competitive compared to biomass or heating pumps.

Considering the common energy certificate it makes absolutely sense to set a commitment for every kind of building. In Austria the energy certificate is still often calculated before a refurbishment measurement is undertaken and not measured after the modernization process is completed. It is recommended that an obligatory measurement of the effect of heat demand reduction and CO2 emissions are taken into account for the energy certificate. It is desired that a database for all refurbishment actions in whole EU is set up to exchange knowledge about used technology and their effects as well as a table with cost calculation to prevent the abuse of high renovation costs. The energy certificate should be extended to other energy-consuming factors for a building on a specific site. For instance the accessibility to public transport services (and not only accessible by car), the compactness of a building or the individual energy consumption by products should be taken into account. Also periodically measurements of heating behaviour (rebound effect) should be considered as the performance of a house may change over time. It is still identified that after a refurbishment people tend to increase room temperature or do not behave energy efficient (doors and windows longer open than before in winter).

Austria is still on a very good way to reach its climate goals (except transportation). A lot of directives, laws and strategies are available to promote more sustainability with regard to energy consumption and energy efficiency. The OIB 6 and building codes seem to be very restrictive. A success was the harmonization of the building codes and the common regulations of OIB instead of restrictions for every province (spatial planning is in the competence of the provinces for instance which results in 9 different regional planning acts with different targets). The positive development of the building modernization rate owes to the two funding schemes. It is a major incentive for deciding for an investment. An increase of the absolute amount of funding is recommended as the application process is often ended after some weeks of the beginning year (too much demand for funding).

[30] High fixed cost

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