

THE IMPACT OF CLIMATE CHANGE AND ENERGY EFFICIENCY ON HEATING AND COOLING ENERGY DEMAND AND LOAD

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Motivation and content

The building sector and related heating and cooling energy demand is associated with significant energy efficiency potentials. Substantial efforts are taken to tap these potentials. On the European level, in particular the energy performance of buildings directive (EPBD recast) requires member states to improve the thermal efficiency of the building stock. At the same time, climate change has a direct impact on heating and cooling energy demand and on the penetration of air conditioning. Previous work has shown, that the additional energy demand for cooling in most scenarios is expected to be lower than the reduction for heating due to climate change (Bednar-Friedl, 2013), (Kranzl et al., 2010), (Pretenthaler and Gobiet, 2008). However, the possible impact on overall electricity loads is still an open question and to be investigated.

The key research question of this paper is: What is the impact of climate change and energy efficiency on heating and cooling energy demand and resulting electricity load in Austria?

This leads to the following sub-questions:

- What are climate signals in different climate scenarios effecting heating and cooling energy demand in Austria?
- What are non-climatic drivers of energy demand for heating and cooling in the Austrian building sector? What drives the uptake of renovation activities and energy efficiency measures in the building sector in different scenarios? What drives the penetration of air conditioning in different building categories of the Austrian building stock?
- What is the impact of these factors on resulting overall energy demand and electricity load profiles?

The paper builds on the results of the project PRESENCE (Power through resilience of energy systems: energy crises, trends and climate change) in the frame of the Austrian climate research programme, supported by the Austrian climate and energy fund. The project is completed end of 2013.

Methodology

Data of three regional climate models, the Aladin, the RegCM3, and the REMO model, each driven by GCMs using the A1B scenario, were used. Three temperature cluster and two irradiation cluster were defined for July ($x < 18^{\circ}\text{C}$, $18^{\circ}\text{C} < x < 22^{\circ}\text{C}$, $x > 22^{\circ}\text{C}$, $x < 50 \text{ W/m}^2$, $x > 50 \text{ W/m}^2$) and two temperature and irradiation cluster for January ($x < 15^{\circ}\text{C}$, $x > 15^{\circ}\text{C}$, $x < 230 \text{ W/m}^2$, $x > 230 \text{ W/m}^2$). This resulted in a set of regional climate clusters. For each of those clusters a representative observation site was selected and semi-synthetic climate data sets were derived.

The Austrian building stock was divided into a set of building types based on the typology being used in the model Invert/EE-Lab (see e.g. Müller et al., (2010)). Based on energy balances of the regions

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and data of the building stock and related heating systems in municipalities, this stock of buildings has been further disaggregated into 10 climatic regions, a sub-set of the climate regions derived above, in order to reach a good calibration of energy demand with regional and national energy balances.

The techno-socio-economic bottom-up model Invert/EE-Lab (www.invert.at, Müller, (2012), Kranzl et al., (2013)) was used to develop climate sensitive scenarios of the heating and cooling energy demand in Austrian residential and non-residential buildings. A module modelling the uptake of AC has been developed: The probability of the installation of AC is simulated as a function of operative temperature within the building and the duration of indoor temperature above certain thresholds.

For each of the relevant building types in the different climate regions, load profiles for heating, hot water and cooling energy needs have been derived based on Bednar, Neusser (2013). Load profiles are aggregated to the overall building stock and the related scenarios.

Three scenarios until 2080 have been developed: (1) a grey scenario based on existing policy instruments, (2) a green scenario with a higher uptake of renewable heating systems and (3) a blue scenario with a higher uptake of efficiency and renewable energy measures. In particular, these efficiency measures include shading devices and other measures reducing cooling loads. Each of these scenarios have been calculated with the three climate scenarios compared to constant climate.

Results

The preliminary results show that even with existing policy instruments and building codes, useful heating energy demand could be reduced by about 40% until 2050 and by about 60% until 2080. The impact of climate change in these scenarios leads to an additional reduction of useful heating energy demand until 2050 by about 4-7% and until 2080 by 6-10%. In the blue scenario, heating energy demand could be reduced by about 60% in 2050 and 85% in 2080 and climate change signals lead to a further reduction of about 3-5% (2050) and 2-5% (2080). Useful energy demand for cooling (not taking into account the stronger penetration of AC) increases from currently about 5 TWh to 8-12 TWh. However, the lower boundary only can be achieved with strong measures to reduce cooling loads (e.g. shading devices). If such measures are not taken, the insulation measures focusing only on a reduction of heating energy demand can even lead to a higher demand for cooling. The climate signal leads to an increase of the useful cooling energy demand by 25%-50% in 2050 and 50%-90% in 2080. However, the crucial point is that the penetration of AC could strongly increase due to heat waves. Due to this increase of AC penetration, the electricity consumption increases by a factor of 4 to 8 in the different scenarios. In the upper range, this could lead to very high maximum cooling loads in the range of 4-5 GW. The full paper will include results on the volatility and range of cooling loads in the different climate scenarios and conclusions regarding the relevance of adaptation measures in the building sector. In particular, we will show how the uptake of shading devices can strongly reduce the cooling loads and related energy demand.

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