# Assessment of heating and cooling demand of buildings as part of a regional analysis of shallow geothermal potential

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**Keywords:** sustainability, GIS data, energy management, primary energy, renewable energy, efficiency, CO2 emissions, thermal rehabilitation measures

## ABSTRACT

Existing studies on the potential of shallow geothermal energy mostly deal with the technical capacity of gaining energy out of the underground and do not take into account other limiting factors such as e.g. regeneration of the underground, local energy demand or housing patterns. Looking at a comprehensive utilisation of geothermal installations it is also of high importance to focus on negative effects due to interactions between those installations. Therefore, it is necessary to determine the energy demand and load for heating and cooling not only for an area but on a buildings level. Due to data privacy, lack and poor quality of existing data, gaining the required input values for the calculation of the heating and cooling demand is often not feasible or at least cumbersome. In this paper, the authors present a methodology to determine the energy demand for heating and cooling of buildings with a minimum of input data. The estimated demand is used to assess a sustainable shallow geothermal utilisation of the underground on a regional basis.

Although the presented software tool is developed to get input data for potential studies on shallow geothermal energy, there is a larger field of applications to investigate the effects of heating energy management in a settlement area. To show the possible range of applications of the tool, an alpine village was chosen for a study on effects of thermal rehabilitation measures at buildings and its influence on shallow geothermal installations, primary energy demand, additional electrical energy demand, quote of renewable energy and $CO_2$ emissions.

For the case study it is shown that it is advisable to force the redevelopment of buildings with a construction year up to 1980 to lower the total primary energy demand for heating. Rehabilitation of newer buildings only has a marginal effect in the reduction of heating energy consumption and thus is economically not worthwhile. The results also indicate to do further investigation to decide whether geothermal installations or alternative energy sources such as biomass are the best choice to raise the quotient of renewable energy in the total primary energy demand.

## 1 INTRODUCTION

Shallow geothermal energy is rated as renewable and thus as one of the sustainable energy sources due to the regeneration by the sun and the geothermal heat flux. But do we really use this source of energy in a sustainable way?

Existing studies on the potential of shallow geothermal energy mostly deal with the technical capacity of gaining energy out of the underground and do not take into account other limiting factors. The main focus in these studies is on modelling the geology of the investigated area and defining an achievable abstraction capacity by using national guidelines (e.g. Ondreka, Rüsgen, et al., 2007 and Geologischer Dienst NRW, 2002). Only one Austrian study (Ostermann, Götzl, et al., 2010) considers the energy demand and the space requirement of geothermal installations and opposed it to the technical potential to get a useable potential, respectively a ratio of energy coverage. However, the the impact of housing patterns as described by Urich et al. (2010) is not taken into account as the study is carried out with a raster based approach and thus ignoring the distribution of buildings.

In the "ACoRE A1" project we are working on a holistic approach to determine the shallow geothermal potential of a region. We identified important environmental, technical and socio-economic factors and bring them together in an integral GIS-based model (see Figure 1). Therefore, many factors such as hydro-geological conditions and the thermal regeneration of the underground have to be taken into account. Furthermore, the heating and cooling demand at a buildings level is of significant importance. This energy demand decides whether a shallow geothermal utilisation for a building is worthwhile or not and what kind of installation is applicable. Additionally, the amount of energy, extracted or brought into the subsurface, and its spatial distribution is of interest when we consider the interactions between the

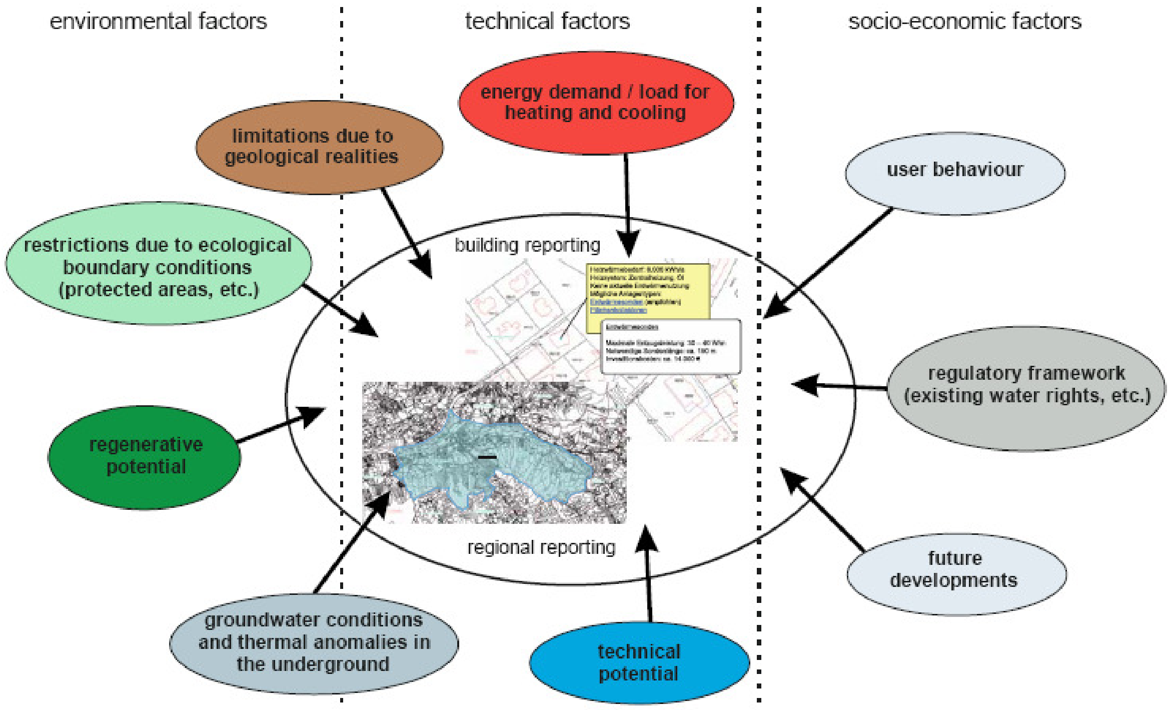


**Figure 1: Holistic approach to the shallow geothermal potential**

geothermal installations and the regeneration of the underground. This is the reason why an object (building) based approach is used herein instead of a raster based approach as e.g. used by Ostermann et al. (2010).

To calculate the energy demand of a building accurately, a lot of detailed input data is required. The geometry of the building as well as material properties, internal and external energy inputs and more data are needed in detail. In general, this means a lot of manual work that is very time-consuming, even for only one building. For a regional analysis, where thousands of buildings have to be calculated, a detailed data collection and thus an accurate calculation is not feasible. To solve this problem, the authors developed a methodology to determine the energy demand for heating and cooling of buildings by utilizing only input data that is usually available. The estimated demand is used to assess a sustainable shallow geothermal utilisation of the underground on a regional level.

Although the presented software tool is developed to gather input data for estimating the potential of shallow geothermal energy, we want to show in a case study that there is a larger field of applications. Therefore, effects of rehabilitation measures on primary energy demand, quotient of renewable energy and $CO_2$ emissions where investigate in an alpine city.

## 2 METHODS AND DATA

As the described tool is still under development, some of the calculations are simplified (e.g. no differentiation between residential and commercial buildings, user behaviour is not considered, etc.). Also the methodology for assessing the cooling demand is not implemented yet. Thus only the part of assessing the energy demand for heating is described in this paper.

First step of the evaluation of the heating demand is to complete the used input data. Next we need to determine the geometry of the buildings to assess the heating demand and peak load. These results are used for further investigations concerning primary energy demand, quotient of renewable energy and $CO_2$ emissions. Furthermore, the effects of thermal rehabilitation measures are tested.

### 2.1 Input data

One major aim of the method is to obtain reasonable results with a minimum of input data. Therefore, missing data is reconstructed or estimated, respectively.

As geometric input GIS data, providing horizontal projections of the buildings is used. The installed heating system, the number of floors and the year of construction are the required building attributes. This attribute data can be obtained from the GWR database (Austrian register of buildings and flats). Buildings with a stated gross floor area of less than 75 m² are deleted as these objects are unlikely to be used for residential or commercial purpose.

As the intention is to use the presented tool for large areas with numerous cities and villages no data cleansing was done for the case study. Just missing data was reconstructed, based on statistical distributions. E.g. missing data for the construction years is sampled from the age distribution for buildings within a region. To ascertain the effect of the reconstruction this was executed 100 times.

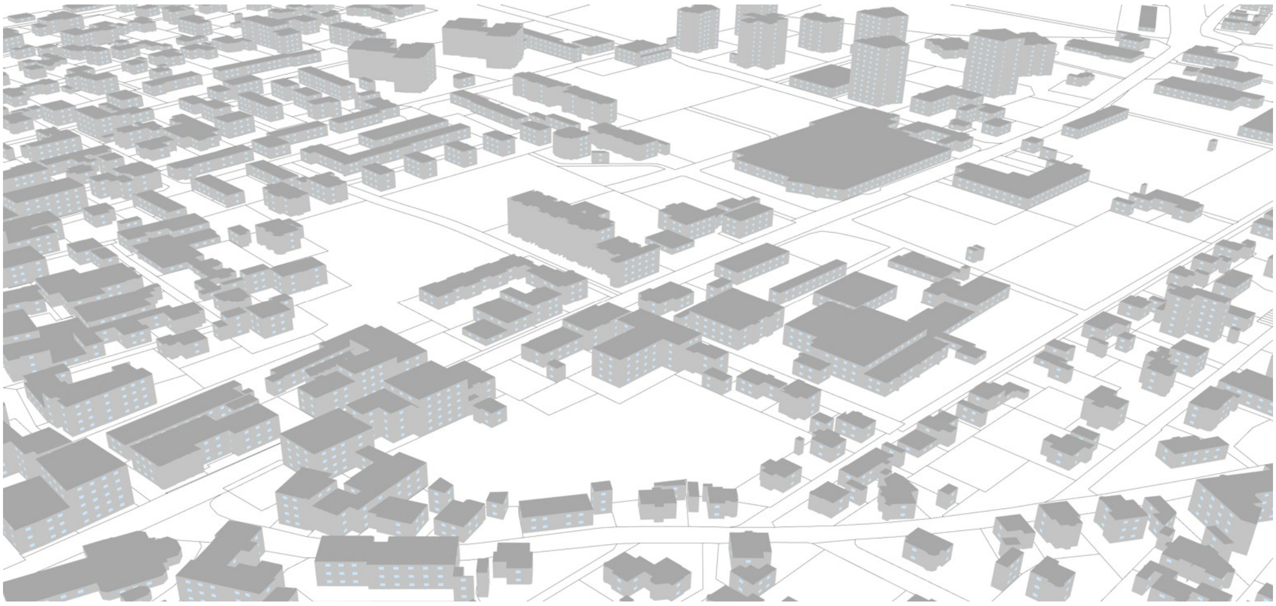

**Figure 2: 3D model cutout of the test city (Urich and Rauch, 2012)**

Also data on the installed heating system had to be reconstructed. The values provided in the existing dataset are "oil", "gas", "biomass" and "heat pump". The value "heat pump" is supposed to be a shallow geothermal installation. As missing data is likely to be related to older buildings, where usually no heat pump is installed, "oil", "gas" and "biomass" were added for the absent values. The reconstruction is done by sampling from a normal distribution.

## 2.2 3D modelling of buildings

Next step is to determine the simplified shape of the building, as the geometry of the object is an important input to all other calculations. Therefore the horizontal projections of the buildings are extruded. The height of each building is calculated by the number of floors and a mean floor height of 2.60 m. Windows are built with a standard size and distribution. In the current implementation inclined roofages can only be generated for single buildings. For our case study only flat roofs are used. With the fully developed toolbox, also cellars will be created automatically. Due to missing data only floors above the ground are considered in the case study. The process of 3D modelling is described in detail by Urich and Rauch (2012).

## 2.3 Heating demand/load of buildings

In this paper the energy *demand* for heating is defined as the yearly energy demand, necessary to keep a specific room temperature during the heating period in kWh/a. The energy *load* for heating is defined as the peak energy load, required to ensure a specific room temperature at the annual minimum nominal external temperature (according to EN 12831 this is the lowest two-day mean temperature, which has been registered ten times over a twenty-year period) in kW.

The method described in the next sections follows the EN 12831 "Heating systems in buildings - Method for calculation of the design heat load" (2003) and its national amendment for Austria ÖN H 7500 (2006). Furthermore the Austrian national standards ÖN B 8110-6 "Thermal insulation in building construction – Part 6: Principles and verification methods – Heating demand and cooling demand" (2010) and ÖN B 8110-5 "Thermal insulation in building construction – Part 5: Model of climate and user profiles" (2011) were taken into account.

### 2.3.1 Heating demand

In a building there are different kinds of thermal sources and sinks. Heat fluxes are calculated independently to examine the effects of different measures on the individual components. The heating demand considers transmission and ventilation losses as well as internal and external (solar) energy input during the heating period:

$$Q_{l(h)} = Q_{T(h)} + Q_{V(h)} \quad [1]$$

$$Q_{g(h)} = Q_{i(h)} + Q_{s(h)} \quad [2]$$

$$Q_h = Q_{l(h)} - Q_{g(h)} \quad [3]$$

with:

$Q_{l(h)}$…total amount of losses during heating period in kWh/a

$Q_{T(h)}$… transmission heat losses during heating period in kWh/a

$Q_{V(h)}$…ventilation heat losses during heating period in kWh/a

$Q_{g(h)}$…total amount of energy input during heating period in kWh/a

$Q_{i(h)}$…internal energy input during heating period kWh/a

$Q_{s(h)}$…solar energy input during heating period generated with a solar radiation module (see 2.3.4) in kWh/a

$Q_h$…heating demand in kWh/a.

Transmission heat losses during heating period are calculated by

$$Q_{T(h)} = \frac{1}{1000} \cdot L_T \cdot (\theta_{ih} - \theta_e) \cdot t \qquad [4]$$

and ventilation heat losses during heating period are calculated by

$$Q_{V(h)} = \frac{1}{1000} \cdot L_V \cdot (\theta_{ih} - \theta_e) \cdot t \qquad [5]$$

with:
$L_T$… heat conductance value in W/K (see 2.3.3)
$L_V$… ventilation conductance value in W/K (see 2.3.3)
$\theta_{ih}$…nominal room temperature during heating period in °C (ÖN B 8110-5, table 2)
$\theta_e$…mean external temperature during heating period in °C (OIB-382-011/99, 1999)
t…time in hours per heating period.

For the heating period all months with a mean temperature below 12°C are taken into account. In our case study this is October to April. These are 212 days of heating. The mean external temperature during heating period for these months is 2.63°C.

The internal energy input during heating period is calculated by

$$Q_{i(h)} = \frac{1}{1000} q_{i,h,n} \cdot \overbrace{GFA \cdot 0.80}^{net\ area} \cdot t \qquad [6]$$

with:
$Q_{i(h)}$… internal energy input during heating period kWh/a
$q_{i,h,n}$…specific internal energy input of persons and electronic devices in W/m² net area (ÖN B 8110-5, table 2)
GFA…gross floor area in m²
t…time in hours per heating period.

For buildings with a specific heating load lower than 15 W/m² the value for a passive house is chosen for the specific internal energy input.

### 2.3.2 Standard heating load

For the design of a heating system the peak heating load ($P_{d,h}$ in kW) is required. To calculate the standard heating load, we have to take into account the worst case for heating (no energy input and statistically defined lowest outside temperature).

$$P_{d,h} = \frac{1}{1000} (L_T + L_V) \cdot (\theta_{ih} - \theta_{ne}) \qquad [7]$$

with:
$L_T$… heat conductance value in W/K (see 2.3.3)
$L_V$… ventilation conductance value in W/K (see 2.3.3)
$\theta_{ih}$…nominal room temperature during heating period in °C (ÖN B 8110-5, table 2)
$\theta_{en}$…minimum nominal external temperature in °C (OIB-382-011/99, 1999).

For our case study the minimum nominal external temperature is -16°C.

### 2.3.3 Heat conductance value $L_T$ and ventilation conductance value $L_V$

With the generated building geometry it is possible to compute the heat conductance value $L_T$ [W/K] and the ventilation conductance value $L_V$ [W/K] of the building.

For a simplified calculation, $L_T$ for heating is defined in the ÖN B 8110-6 (2010) as:

$$L_T = \sum_i f_{i,h} \cdot A_i \cdot U_i + L_\psi + L_\chi \qquad [8]$$

with:
$f_{i,h}$… temperature correction factor for building element i (ÖN B 8110-6, Tables 3,4 and 5)
$A_i$…area of the building element i in the building envelope, in m²
$U_i$…("U-value") thermal transmittance of building element i of the building element *i*, in W/m².K
$L_\psi + L_\chi$…conductance value addition for thermal bridges, in W/K

$A_i$ is taken from the 3D model. The values of $U_i$ are excerpted from literature (Pöhn, Pech, et al., 2007, Table 011.10-04 and 011.10-05) and are automatically evaluated for each building element depending on the year of construction and the location of the building.

To simplify the calculation the minimum conductance value addition for thermal bridges (minimum 10% of $L_T$ without $L_\psi + L_\chi$) according to ÖN B 8110-6 (2010) is used to approximate this part of formula 8. This results in:

$$L_\psi + L_\chi = 0.1 \cdot \sum_i f_{i,h} \cdot A_i \cdot U_i \qquad [9]$$

and thus:

$$L_T = 1.1 \cdot \sum_i f_{i,h} \cdot A_i \cdot U_i \qquad [10]$$

The ventilation conductance value $L_V$ [W/K] was approximated by:

$$L_V = c_{p,L} \cdot \rho_L \cdot v_V = 0.34 \cdot v_V \qquad [11]$$

with:
$c_{p,L}.\rho_L$…volume related specific heat capacity of air, in W.h/(m³.K) (= 0.34 for a constant air temperature of 20°C)
$v_V$…air flow rate of heated space in m³/h

For the calculation of the air flow rate of the heated space, window ventilation was assumed.

$$v_V = v_{L,FL} = n_{L,FL} \cdot V_i \qquad [12]$$

with:
$v_{L,FL}$…air flow rate at window ventilation in m³/h
$n_{L,FL}$…energetically effective air exchange rate at window ventilation in $h^{-1}$ (ÖN B 8110-5, table 2)
$V_i$…volume of heated space in m³, calculated on the basis of internal dimensions
The volume of heated space is determined by:

$$V_i = GFA \cdot 2.6 \cdot 0.8 \qquad [13]$$

Automatic ventilation systems and heat recovery are currently not regarded in the model. Air exchange rates due to pressure differences are neglected. At the present state of the model, there is no differentiation between residential and commercial buildings.

### 2.3.4 External energy input – solar radiation

The development of the software module for the solar radiation is not finished yet. This module will apply the 3D model of the buildings to calculate irradiated and shaded areas considering the movement of the sun in the course of the year. Combined with the calculation of the corresponding radiation intensity the solar energy input is evaluated. The solar module is described in detail by Urich and Rauch (2012).

For this study a rough estimation was used to consider the solar energy input. It's assumed that the window area is 10% of the gross floor area of the building. The mean radiation intensity in the test area for the heating period amounts to approximately 1.5 kWh/m² per day. To consider shadowing and reflection a reduction ration of 0.7 was assumed. Only solar energy input during the heating period (212 days) is considered.

## 2.4 Thermal rehabilitation measures

For the case study, six scenarios were created to evaluate the influence of thermal rehabilitation measures (see Table 2). In all scenarios shallow geothermal installations were installed if possible, also in the base scenario.

Rehabilitation measures were realised by changing the U-values (see formula 8) of the buildings as shown in Table 1. These values consider that rehabilitation measures on buildings of different construction periods result in different U-values.

**Table 1: U-values of redeveloped buildings (Ostermann, Götzl, et al., 2010)**

| constr. period | U-values of redeveloped buildings, in W/m²K | | | | |
|---|---|---|---|---|---|
| | **CC** | **OW** | **TC** | **RA** | **W** |
| ≤ 1945 | 0.380 | 0.540 | 0.170 | 0.160 | 1.40 |
| 1946/80 | 0.367 | 0.171 | 0.164 | 0.142 | 1.40 |
| 1981/90 | 0.289 | 0.155 | 0.184 | 0.166 | 1.40 |
| 1991/00 | 0.247 | 0.150 | 0.165 | 0.150 | 1.10 |
| >2000 | 0.232 | 0.141 | 0.140 | 0.131 | 1.10 |

CC…cellar ceiling, OW…outer wall, TC…topmost ceiling, RA…roof area, W…windows

For simplicity and to cut down the computation burden, for the different rehabilitation measures a complete rehabilitation of different construction periods is assumed (e.g. in S2, all buildings with a construction period before 1945 are rehabilitated). However, with the investigated scenario, general trends and extreme values can be determined.

**Table 2: case study scenarios**

| scenario | description |
|---|---|
| S1 | Base scenario: no rehabilitation measures |
| S2 | Rehabilitation measures at all buildings with a construction year ≤ 1945 |
| S3 | Scenario 2 plus rehabilitation measures at all buildings with a construction year between 1946 and 1980 |
| S4 | Scenario 3 plus rehabilitation measures at all buildings with a construction year between 1981 and 1990 |
| S5 | Scenario 4 plus rehabilitation measures at all buildings with a construction year between 1991 and 2000 |
| S6 | Scenario 5 plus rehabilitation measures at all buildings with a construction year >2000 |

According to the flow temperature of the heating system (see 2.5) and the specific heating load, it is decided whether a geothermal installation is feasible or not. For all buildings with a flow temperature equal or less than 55°C and a specific heating load less than 90 W/m², a heat pump installation is intended. When the input data of a building already indicates a heat pump, no further check of the described parameters is done. Heating systems using "biomass" as energy source are not set to "heat pump", as those installations supposed to be already ecological sustainable.

## 2.5 Coefficient of performance (COP), primary energy demand, renewable energy and $CO_2$ emissions

The COP of a shallow geothermal installation depends on the temperature difference between the heat source (in this case shallow underground and groundwater temperature) and the target temperature of the heat pump (see Figure 3). It's assumed, that the target temperature is equal to the flow temperature of the heating system. Thus

$$\Delta T = \theta_{out} - \theta_{hs} \qquad [14]$$

with:
$\Delta T$...temperature spread in K
$\theta_{out}$…flow temperature of the heating system in °C
$\theta_{hs}$…heat source temperature in °C.

For the case study, the mean underground temperature is 10°C. The flow temperature is determined by the construction year of the building as shown in Table 3. The applied values are chosen according to various literatures (e.g. Leven, Neubarth, et al., 2001 / Müller, Biermayr, et al., 2010 / Schnieders, 2005).

**Table 3: construction period and flow temperature of the heating system**

| construction period | flow temperature | |
|---|---|---|
| | not redeveloped | redeveloped |
| ≤ 1945 | 90 | 55 |
| 1946/1980 | 70 | 55 |
| 1981/1990 | 60 | 40 |
| 1991/2000 | 55 | 35 |
| >2000 | 35 | 35 |

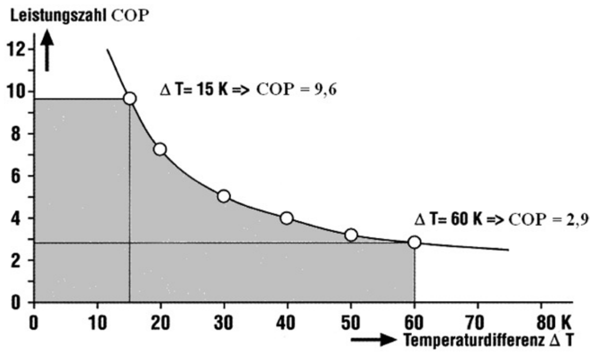


**Figure 3: COP plotted against temperature spread (Österreichischer Wasser- und Abfallwirtschafts-verband, 2009)**

As we know the type of the energy source, the heating energy demand of the building and the COP for the shallow geothermal installation, the primary energy demand, the quote of renewable energy and the $CO_2$-emission are calculated using the conversion factors (see Table 4) of the OIB guideline 6 (2011). Furthermore the additional required electrical energy due to geothermal installations is determined.

**Table 4: conversion factors (OIB, 2011)**

| energy source | $f_{PE}$ [-] | $f_{PE,n.ern.}$ [-] | $f_{PE,ern.}$ [-] | $f_{CO2}$ [g/kWh] |
|---|---|---|---|---|
| **oil** | 1.23 | 1.23 | 0 | 311 |
| **gas** | 1.17 | 1.17 | 0 | 236 |
| **biomass** | 1.08 | 0.06 | 1.02 | 4 |
| **electric energy***  | 2.62 | 2.15 | 0.47 | 417 |

*Austrian electricity mix (OIB, 2011)

For the evaluation of the primary energy demand, the heating energy demand of every building is multiplied with the conversion factor according to the used energy source. For the energy extracted from the shallow underground $f_{PE}$ is set to 1.0. It is assumed that this energy is completely renewable and there are no $CO_2$ emissions due to the use of this energy source. The quote of electrical energy needed for the heat pump is calculated using the COP of the installation.

## 2.6 Case study city

For the case study a real city with a population of about 13.000 and an area of 20 km² was used. The city is situated in an alpine region 500 m a.s.l., therefore alpine climate was considered in the calculations. The total electric energy demand amounts to 60 GWh per year. A study on energy demand for heating of residential buildings calculated a total yearly demand of 95 GWh for the test city.

# 3 RESULTS AND DISCUSSION

To show the possible range of application of the tool, an alpine village was used for a study on effects of thermal rehabilitation measures at buildings and its influence on shallow geothermal installations, primary energy demand, additional electrical energy demand, quote of renewable energy and $CO_2$ emissions.

First of all the distribution of the construction periods of the buildings in the case study is investigated. This distribution is important for the interpretation of the following results. Figure 4 shows that most of the buildings were constructed before the year 1990 with the highest percentage in the period between 1945 and 1980. This means that the majority of buildings do not match actual standards of thermal insulation and thus there is a high potential for thermal rehabilitation measures. The small standard deviation in the boxplot indicates that the influence of completing the input data for the construction year has only little influence on the results.

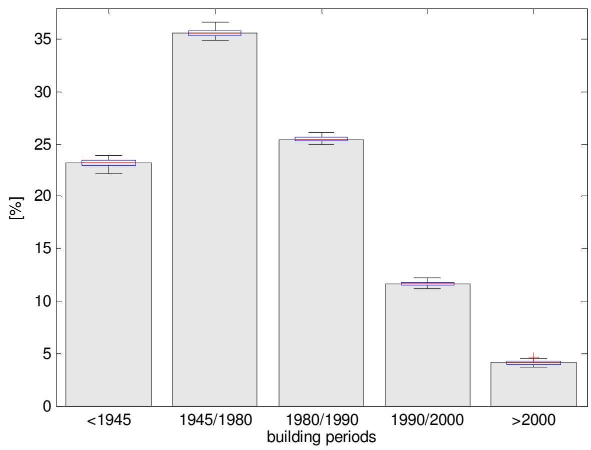


**Figure 4: distribution of buildings in construction periods**

For the base scenario S1 the distribution of the specific heat load of the buildings within the construction periods is analysed (see Figure 5). For the construction periods 1990 to 2000 and older than 2000, there is only a small variation in the distribution. The median values of these periods vary around 100 W/m². These are values that can be expected for buildings of such age. For the older buildings the variation in the distribution is much higher but the median values are still within expected ranges.

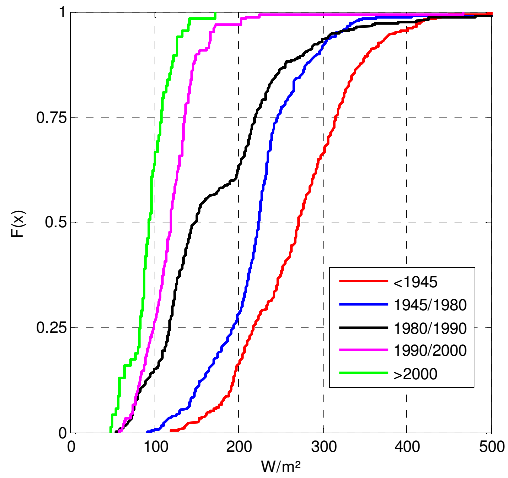


**Figure 5: distribution of specific heat load in the base scenario assigned to construction periods**

Figure 6 shows the influence of rehabilitation measures on the specific heat load for the case study. The high values at the base scenario (S1) can be ascribed to the great number of buildings constructed before 1980 (see Figure 4). Up to this time, thermal insulation of buildings was not a matter of importance. Rehabilitation of those buildings, as supposed in scenario S3, has the maximum effect on the specific heat load. Further rehabilitation measures on newer buildings have only little effect on the specific heat load. A conclusion for our test case administration could be to give financial support for thermal rehabilitation of buildings with a construction year before 1980.

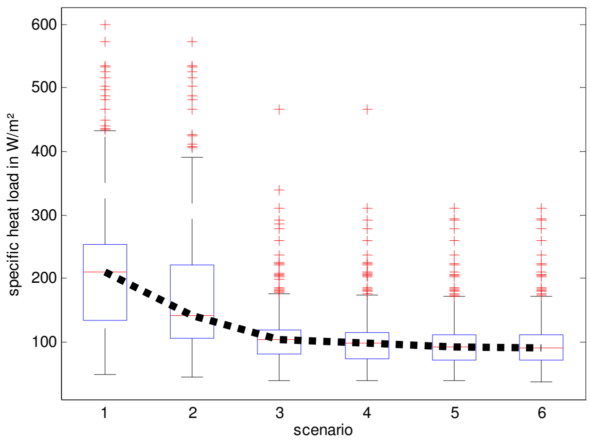


**Figure 6: distribution of specific heat load in all scenarios**

A similar trend can be seen in Figure 7, where the number of possible shallow geothermal installations, as defined in 2.5, is shown. There is a strong increase of possible geothermal installations up to scenario S4, but only a low rate of increase in scenario S5 and S6.

For the calculation of the primary energy demand it is assumed that shallow geothermal installations are attached in all buildings meeting the defined requirements (except buildings, using biomass as energy source).

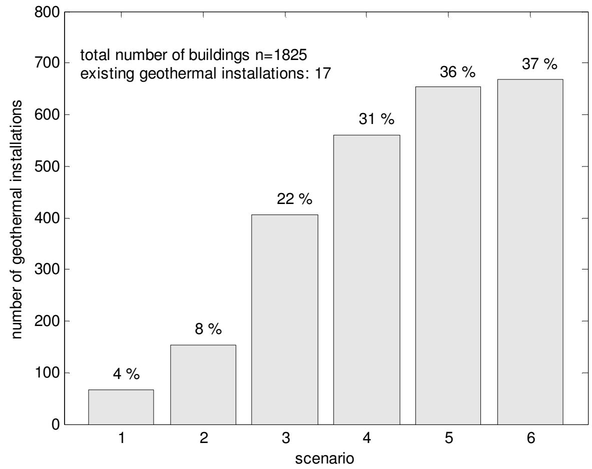


**Figure 7: amount of possible shallow geothermal installations**

In Figure 8 a major drop of energy demand can be seen up to scenario S3. There is still a reduction of the energy demand in the scenarios S4, S5 and S6 but only to a minor degree. The quotient of renewable energy increases from 24% in scenario S1 to 45% in scenario S4. There is only a minimal further increase in the scenarios S5 and S6. This indicates that neither rehabilitation measures, nor changing the heating system to a shallow geothermal installation for buildings constructed after 1990 have significant further positive effects in the energy consumption. Additional energy saving could be reached by developing buildings to passive house standard which is not considered in this study.

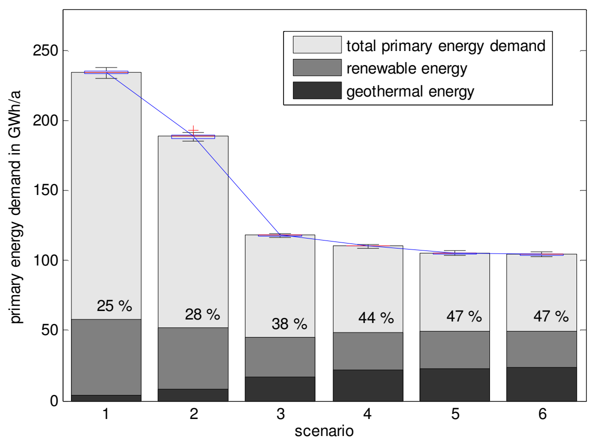


**Figure 8: primary energy demand for heating, quotient of renewable energy**

Also of interest is the saving of $CO_2$ emissions due to rehabilitation measures. Figure 9 shows that there is a main reduction of $CO_2$ emissions at scenario S3. The additional savings in the following scenarios are limited to a maximum of further 10%.

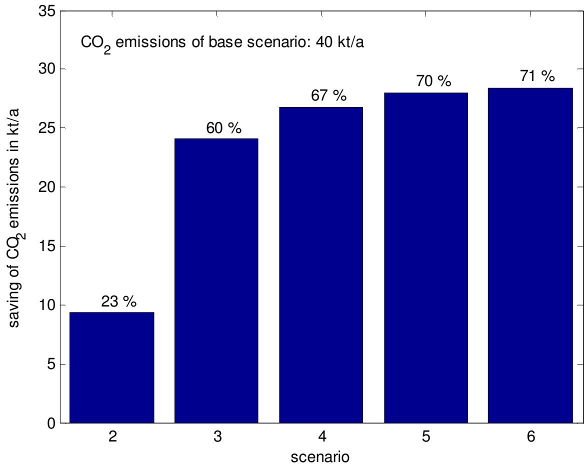


**Figure 9: savings of $CO_2$ emissions**

Installing shallow geothermal heating systems implies an additional demand on electricity. The amount of this additional demand is an important information for electric supply companies. In scenario S4 the demand of electricity to operate the geothermal installations sums up to approximately 8 GWh per year. This means an increasing demand in electric energy of more than 10% for our case study.

The electricity mix is an important factor for the primary energy demand of shallow geothermal installations. For the calculations the values of the Austrian electricity mix where used. Looking at the primary energy demand only 18% of the mix can be counted as renewable at the moment (OIB, 2011). Assuming an increase of this value to 35% raises the quote of renewable energy for heating at additional 3 percentage points in all scenarios.

An important factor for the energy demand for heating is the room temperature. According to ÖN B 8110-5, table 2 a nominal room temperature of 20°C is used for our calculation. Looking at the ordinary user behaviour a room temperature of 21°C seems to be more realistic. Assuming this value, results in an increased primary energy demand of additional 6% in all scenarios.

To compare the efficiency of shallow geothermal energy to the usage of biomass all geothermal installations where replaced by biomass as energy source. With this setting the quotient of renewable energy rises in the scenarios slightly between 4 and 10 percentage points. Also the saving of $CO_2$ emissions increases at 5 to 7 percentage points. These results indicate that it is important to look at further factors in more detail, (achievable COP, local availability of biomass, combination of geothermal energy and photovoltaic, etc.) to decide whether biomass or geothermal energy as heat source is advisable to gain sustainability in heating.

The calculated energy demand and peak load is used to design shallow geothermal installations for the buildings. Figure 10 shows the thermal anomalies due to groundwater heat pump installations. Those systems were only installed where not conflicting with other installations. This conflict free placement can also be done with borehole heat exchangers. At the moment the results of this placement are not considered in the amount of shallow geothermal installations but will in future. The placement module is described in more detail by Urich and Rauch (2012).

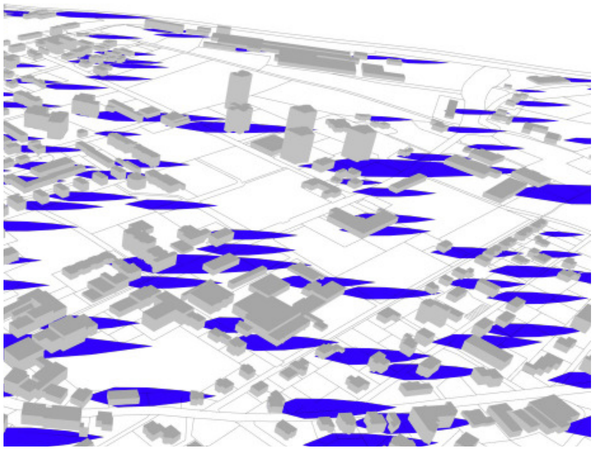

**Figure 10: thermal anomalies due to groundwater heat pump installations (Urich and Rauch, 2012).**

## 4 CONCLUSIONS AND OUTLOOK

For a regional analysis of shallow geothermal potential the heating demand of buildings is an important factor. As this data is hardly available, it is necessary to calculate it using existing data. The presented method can be applied in large areas with a large number of buildings and gives results with only minimal effort. Although the tool is developed for studies on shallow geothermal energy the application spectrum is much larger. As shown in this paper different analysis concerning energy management in a community can be done. At the moment the software is used as scientific tool but there is a great potential to extend it to a decision support system for policy-makers and energy supply companies.

For the case study it is shown that it is advisable to force the redevelopment of buildings with a construction year up to 1980 to lower the total primary energy demand for heating. Rehabilitation of newer buildings only has a marginal effect in the reduction of heating energy consumption and thus is economically not worthwhile. The results also indicate the need for further investigations to decide whether geothermal installations or alternative energy sources such as biomass are the best choice to raise the quotient of renewable energy in the primary energy demand.

In continuation of this work further emphasis will be put on the validation of the results. Once the results of the heating demand calculation are proved, the tool will offer the possibility to achieve the data basis for energy management plans.

To get more accurate results for single buildings the calculation of ventilation losses will be improved to consider ventilation due to pressure differences as described in EN 12831. Furthermore, there will be a differentiation between residential and office buildings. Beside the heating demand also the cooling demand of the buildings will be evaluated. Due to rising demands in room climate conditioning the cooling demand for buildings will be of high importance in future. Further development of the tool will also allow determining the energy demand for hot water.

For the intended usage of the tool, gaining input data for a regional shallow geothermal potential, the described further developments are sufficient. Of course, there is the possibility to calculate the heating and cooling demand in high detail for every building as it is already possible with special software. But it must be kept in mind that a huge amount of detailed input data is necessary for such undertaking.

## REFERENCES


FNA 058 Heizungsanlagen (2003) ÖNORM EN 12831 - Heating systems in buildings - Method for calculation of the design heat load.

FNA 058 Heizungsanlagen (2006) ÖNORM H 7500 - Heating systems in buildings - Method for calculation of the design heat load (National amendment reffering to ÖNORM EN 12831).

FNA 175 Wärmeschutz von Gebäuden und Bauteilen (2011) ÖNORM B 8110-5 - Thermal insulation in building construction - Part 5: Model of climate and user profiles.

FNA 175 Wärmeschutz von Gebäuden und Bauteilen (2010) ÖNORM B 8110-6 - Thermal insulation in building construction - Part 6: Principles and verification methods - Heating demand and cooling demand.

Geologischer Dienst NRW (2002) *Geothermiepotential NRW*, Krefeld, Geologischer Dienst NRW.

Leven, B., Neubarth, J., and Weber, C. (2001) Ökonomische und ökologische Bewertung der elektrischen Wärmepumpe im Vergleich zu anderen Heizungssystemen. [online] http://elib.uni-stuttgart.de/opus/volltexte/2003/1427/ (Accessed March 20, 2013).

Müller, A., Biermayr, P., Kranzl, L., Haas, R., Altenburger, F., Bergmann, I., Friedl, G., Haslinger, W., Heimrath, Richard, Ohnmacht, R., and Weiss, W. (2010) *Heizen 2050 - Systeme zur Wärmebereitstellung und Raumklimatisierung im österreichischen Gebäudebestand: Technologische Anforderungen bis zum Jahr 2050*,

OIB (2011) OIB-Richtlinie 6, Energieeinsparung und Wärmeschutz.

Ondreka, J., Rüsgen, M. I., Stober, I., and Czurda, K. (2007) GIS-supported mapping of shallow geothermal potential of representative areas in south-western Germany--Possibilities and limitations. Renewable Energy, **32**(13), 2186–2200.

Ostermann, V., Götzl, G., Zottl, A., Heimrath, R., Novak, A., and Kalasek, R. (2010) GEO-Pot, Überregionale, interdisziplinäre Potenzialstudie zur Erhebung und Darstellung des oberflächennahen geothermischen Anwendungspotenzials auf Grundlage eines regelmäßigen Bearbeitungsrasters - Endbericht.

Österreichischer Wasser- und Abfallwirtschaftsverband (2009) *ÖWAV-RB 207: Thermische Nutzung des Grundwassers und des Untergrunds – Heizen und Kühlen*, Wien, Selbstverlag des Österreichischen Wasser- und Abfallwirtschaftsverbandes.

Pöhn, C., Pech, A., Bednar, T., and Streicher, W. (2007) *Bauphysik. Erweiterung 1, Energieeinsparung und Wärmeschutz; Energieausweis - Gesamtenergieeffizienz*, Vienna, Springer-Verlag/Wien.

Sachverständigenbeirat "Energieausweis" (1999) OIB-382-011/99 Anhang zum Leitfaden für die Berechnung von Energiekennzahlen - Klimadaten.

Schnieders, J. (2005) *Dynamisches Verhalten und Wärmeübergabeverluste von Flächenheizungen*, Passiv Haus Institut.

Urich, C. and Rauch, W. (2012) PowerVIBe - Energy and Technology Strategies Benchmarking, Endbericht. [online] www.dynamind-toolbox.org.

Urich, C., Sitzenfrei, R., Möderl, M., and Rauch, W. (2010) Einfluss der Siedlungsstruktur auf das thermische Nutzungspotential von oberflächennahen Aquiferen. Österreichische Wasser- und Abfallwirtschaft, **62**(5-6), 113–119.