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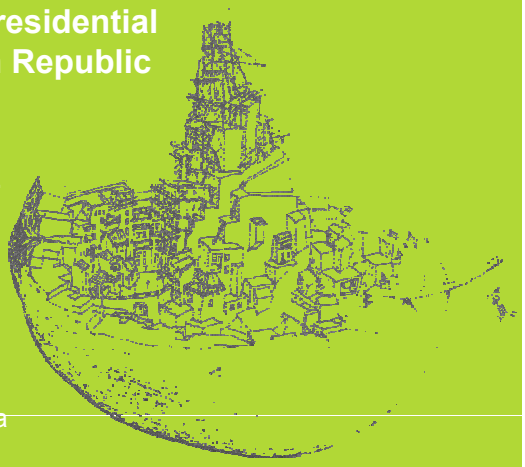
Universität für Bodenkultur Wien
Department für Bautechnik und Naturgefahren

Energy consumption for domestic hot water in residential buildings: Evidence from Austria and the Czech Republic



IMPLEMENTING THE 2020 ENERGY AND CLIMATE PACKAGE
15TH APRIL 2009, KAROLINUM – IMPERIAL HALL

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2008
Energy consumption for domestic hot water in residential buildings: Evidence from Austria and the Czech Republic

2009
Solar thermal energy generation for new and existing building estates

Energy consumption for domestic hot water in residential buildings: Evidence from Austria and the Czech Republic

- Water heating causes **high energy consumption** in residential buildings,
- In passive houses and low-energy-houses this energy consumption can even be **higher than the energy consumption for space heating**,
- The **user needs are rising** and the actual energy consumption for hot water is often **underestimated** in the planning stage.

Objectives

- **examine planning methods** and the **actual energy consumption** for domestic hot water in the Czech Republic and Austria,
- present **concepts** and **pilot projects** regarding eco-friendly and energy efficient solutions for solar systems and new building concepts.

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Current situation in Austria

- **pioneer** in the realization of eco-friendly and energy efficient houses,
- the **highest rate of installed solar collectors** per resident in Europe besides Cyprus and Greece [WEISS et al., 2007]. The total area of installed solar collectors is 3.3 million m² and is increasing by approximately 0.3 million m² per year [FANINGER, 2007].

	Collector Yield 2005 [GWh/a]		Total capacity installed at the end of 2005 [MW_{th}]		Annual installed capacity 2005 [MW_{th}]	
	Hot water, space heating	Total (incl. pools)	Glazed collectors	All collectors	Glazed collectors	All collectors
Austria	860	995	1690	2106	163	168

Solar heat market in Austria according to the International Energy Agency [WEISS et al., 2007].

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Hot water energy demand in residential buildings

- energy consumption for hot water in residential buildings usually **fluctuates**,
- depends on the individual **behaviour of users** as well as the installed **sanitary equipment**,
- the **size and frequency** of use of a bathtub influences a household's energy, consumption, as do the installed **fittings**,
- the use of **fittings** entails a lot of **optimisation potential** for planers and constructors,
- the **distribution concept** for hot water is important factor for the energy efficiency.

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Planning figures for the energy demand of hot water generation in residential buildings

USEFUL ENERGY	
FORMULA	**COMMENTS, SOURCE**
25 l/(Pers.d) à 60 °C	PHPP-Standard value for passive houses [PHI (2007)]
10-20 l/(Pers.d) à 60 °C	Low value for residential units [RECKNAGEL et al.,1997]
20-40 l/(Pers.d) à 60 °C	High value for residential units [RECKNAGEL et al.,1997]
40-80 l/(Pers.d) à 60 °C	Highest value for residential units [RECKNAGEL et al.,1997]
12,5 kWh/(m^2_{GFA}.a)	Klima:aktiv-house criteria [BMVIT et al., 2007]
10 kWh/(m^2_{UFS}.a)	Total-Quality (Version 2) target value for low-energy houses and passive houses [BRUCK, 2002]
30 kWh/(m^2_{UFS}.a)	Total-Quality (Version 2) for usual existing houses [BRUCK, 2002]
35 Wh/(m^2_{BF}.d) BF = 0,8 * GFA	ÖNORM B 8110-5, 2007-08-01, P. 8
1 kWh/(Pers.d)	Low water demand for apartments [FREY et al., 1994, DB.8]
3 kWh/(Pers.d)	High water demand for apartments [FREY et al., 1994, DB.8]
12 * (33+0,83 * UFS) [kWh/a]	Estimation of water demand of residential buildings [OBERHUBER et al., 2005, P. 213]

GFA = Gross floor area, UFS = Useable floor space

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Passive house student's hostel Molkereistrasse in Vienna, Austria

Architects: Baumschlager Eberle P.ARC

[Source: Roman Smutny]

Largest Passive House worldwide (09.2005)

Molkereistrasse

- gross floor area of 10,527 m²
- treated floor area of 7,715 m² according to the calculation by PHPP
- 133 apartments

Hot water generation concept

- district heating, drinking water becomes heated in two central water heating storage tanks (each 1.5 m³ and 25 cm insulation)
- distribution of warm water by one pipe system instead of a two pipe system (closed circuit).

Calculated hot water energy demand

- estimated with 25 liters per person and day with a water heating temperature of 60°C,
- useful energy demand for hot water amounts to 14 kWh/(m²TFA.a) per m² treated floor area according to the calculation by PHPP [PHI, 2007],
- end energy demand for hot water was calculated with 17 kWh/(m²GFA.a) (80 % degree of utilisation for thermal distribution and storage),

Planning figures for the energy demand of hot water generation for 280 residents of the building Molkereistrasse

USEFUL ENERGY		
FORMULA	**HOT WATER ENERGY DEMAND [kWh/(m^2_{GFA}·a)]**	**COMMENTS, SOURCE**
25 l/(Pers.d) à 60 °C	**14**	PHPP-Standard value for passive houses [PHI (2007)]
25 l/(Pers.d) à 60 °C	14	Low value for homes, pensions [RECKNAGEL et al.,1997]
50 l/(Pers.d) à 60 °C	28	High value for homes, pensions [RECKNAGEL et al.,1997]
50 l/(Pers.d) à 60 °C	28	Low value, hotel room + shower [RECKNAGEL et al.,1997]
100 l/(Pers.d) à 60 °C	56	High value, hotel room with shower [RECKNAGEL et al.,1997]
12,5 kWh/(m^2_{GFA}.a)	12,5	Klima:aktiv-house criteria [BMVIT et al., 2007]
10 kWh/(m^2_{UFS}.a)	12,5	Total-Quality (Version 2) target value for low-energy houses and passive houses [BRUCK, 2002]
30 kWh/(m^2_{UFS}.a)	37,5	Total-Quality (Version 2) for usual existing houses [BRUCK, 2002]
35 Wh/(m^2_{BF}·d) BF = 0,8 * GFA	10,2	ÖNORM B 8110-5, 2007-08-01, P. 8
1 kWh/(Pers.d)	10	Low water demand for apartments [FREY et al., 1994, DB.8]
3 kWh/(Pers.d)	29	High water demand for apartments [FREY et al., 1994, DB.8]
12 * (33+0,83 * UFS) [kWh/a]	6,4	Estimation of water demand of residential buildings [OBERHUBER et al., 2005, P. 213]

Remark: GFA = Gross floor area, UFS = Useable floor space.

Molkereistrasse: Measured hot water energy consumption

END ENERGY	**DEMAND VALUES according to PHPP-Calculation**		**MEASURED VALUES 2006**	**MEASURED VALUES 2007**
	Per TFA [kWh/(m² a)]	Per GFA [kWh/(m² a)]	Per GFA [kWh/(m² a)]	Per GFA [kWh/(m² a)]
Hot water	23	17	35	35

Remark: GFA = Gross floor area, TFA = Treated floor area

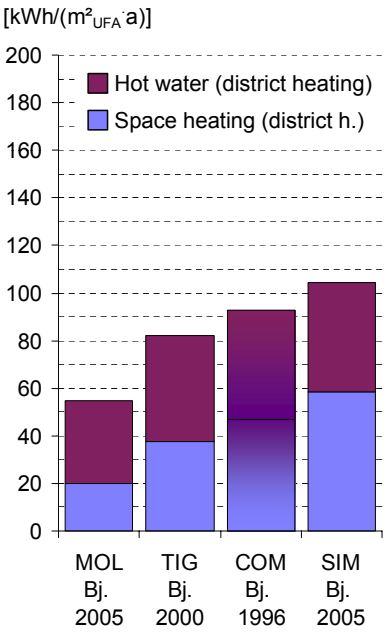
The design value for hot water generation (25 litres with 60 °C per person and day as an ordinary value for conventional housing estates) is approximately half of the actual consumption value.

Therefore an appropriate design value for water heating in student's hostels should be 50 litres with 60 °C per person and day, which corresponds to a low value for hotels with shower [RECKNAGEL et al., 1997].

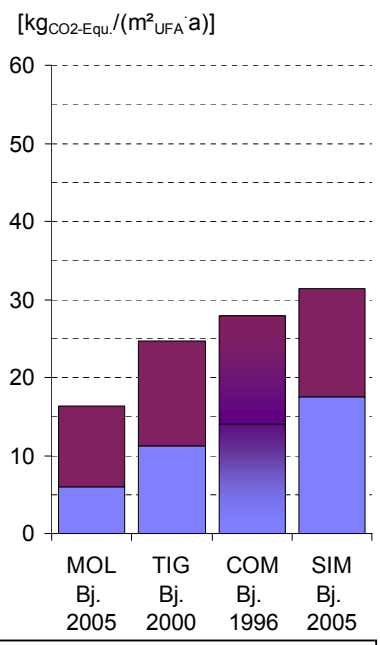
COMPARISON of VIENNES STUDENTS' HOSTELS

Sept.05 – Aug.07, per usable floor area (UFA), actual climate, GEMIS-Factors for Vienna

PRIMARY ENERGY CONSUMPTION not renewable



GREENHOUSE GAS EMISSIONS



PE_{ne} - factor	**GHG-Emission - factor**
District h.: 0,639 kWh/kWh	District h.: 0.192 $kg_{CO2-Equ.}$/kWh

Source: GEMIS 4.42-AT

LIMITED COMPARABILITY

Reference = Actual Value (ISO 14040f)

Differences in

- **living comfort,**
- **building services**
- **equipment**

Additional value of Molkereistrasse:

- Thermal quality,
- Air quality,
- Daylight quality,
- Usable floor area

Molkereistrasse built in 2005 (MOL),

Tigergasse built in 2000 (TIG),

Comeniusgasse built in 1996 (COM)

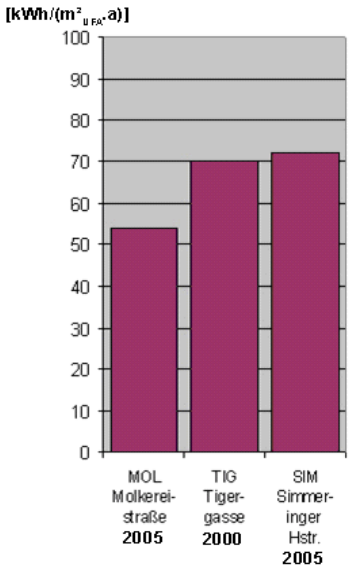
Simmeringer Hauptstrasse built in 2005 (SIM).

All supplied with district heating.

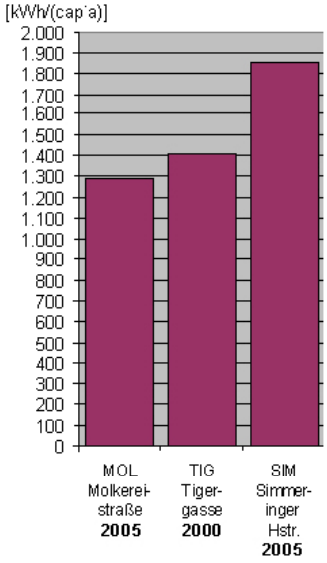
Medium values of the period 09.2005 - 08.2007.

End energy consumption for hot water generation per useful floor area (UFA) and per capita

END ENERGY CONSUMPTION for HOT WATER GENERATION per useful floor area
(average value 2005/06, 2006/07)



END ENERGY CONSUMPTION for HOT WATER GENERATION per capita
(average value 2005/06, 2006/07)



Molkereistrasse: Conclusions

- energy consumption for hot water generation is relatively small (in comparison to the other documented student's hostels), but still high compared with the calculated energy demand and the experienced values from residential buildings.

- possible optimisation potentials are:

  - change of used fittings and shower heads,
  - reduction of hot water pressure,
  - hot water heat recovery,
  - Insulation of distribution pipes.
  - for the realization of sustainable student's hostels, the passive house concept should be implemented comprehensively including concepts to reduce the consumption of energy for hot water generation and electrical energy.

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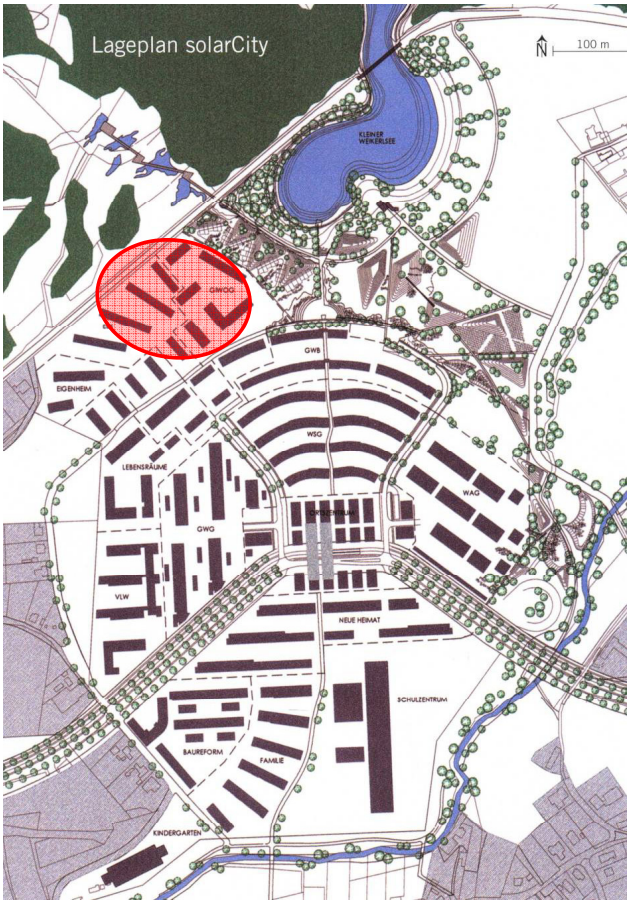
BOKU

Sustainable urban development project solarCity Linz Pichling, Austria

solarCity Linz Pichling, Austria



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solarCity Linz Pichling, Austria

House 2, 4-7:
Low energy House
Heating energy demand:
30-32 kWh/m²a
Standard-heater

House 3:
Almost-Passivehouse
Heating energy demand:
< 20 kWh/m²a
Decentral ventilation
smaller heater

HOUSE 1:
Passivehouse
Heating energy demand:
< 15 kWh/m²a
Decentrale ventilation mit earth preheating unit

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solarCity Linz Pichling, Austria

- Individual access to the sun is achieved by making the dwellings as sunny and bright as possible, with large window areas,
- passive uses of solar energy, such as sun-facing windows and conservatories, provide greater living comfort and better heating of the respective rooms in winter,
- Solar panels on the roofs for hot water.

Calculated hot water energy demand

- maximum energy demand of the buildings (44 kWh/(m²GFA.a)),
- at least 34 % of the hot water generation provided by means of solar energy.

Measured hot water energy consumption

- average value of all residential buildings of the solarCity for total end energy consumption for hot water generation is 25 kWh/(m²GFA.a),
- This total value consists of 65 % energy consumption from district heating and 35 % energy consumption from solar energy.

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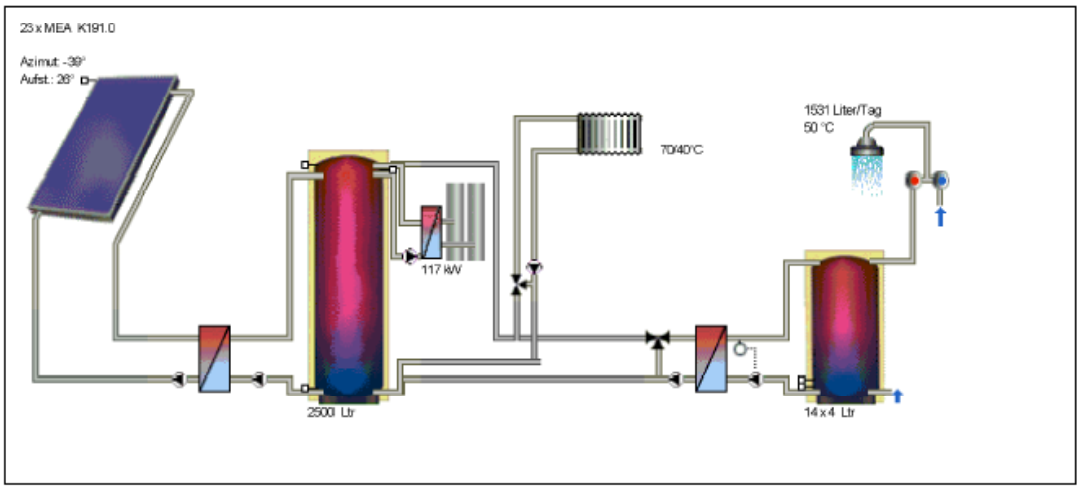
solarCity Linz Pichling, Austria



solarCity Linz Pichling, Austria

Because of the analysis of the energy consumption for hot water generation, some results and conclusions can be made:

- increase of active solar gain through readjustment of the solar thermal system,
- minimisation of distribution losses through insulating the distribution pipes,
- solar thermal energy concepts can be optimized by simulations with the software TRNSYS and successfully tested in practice,
- online monitoring of solar systems can prove to be valuable for owners and occupants, providing safeguards against failure and malfunction and helping to adjust the control settings and thereby increase solar gains.

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Current situation in Czech Republic

- **lack of serious information** on real hot water consumption,
- respected values, if needed for energy balancing and solar systems design come from **German VDI 2067**,
- The only official source is Czech national standard for the design of water heaters (CSN 06 0320),
- For realistic DHW balancing, the values are **not usable** due to the target of the standard to provide the safe calculation of heater power and volume (maximum, peak values). Application of these data in design stage of solar systems results in oversized systems and consequently in their problematic operation.

Objectives

- **compiling** the correct and reliable domestic **hot water consumption data** (hot water and energy demand – absolute values, specific values per person or per m^2, annual profile – relative values in %),
- **compiling** the associated **energy demands** to form hot water guidelines for residential and tertiary sector in Czech Republic for use in the design stage of solar systems planning,
- **reference data tables** should be published and compared with similar reference tables from Austria and Germany. Data can be also used for energy performance evaluation in the frame of building certification process in both countries.

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PROJECT 2009:
Solar thermal energy generation for new and existing building estates

- Solar thermal energy usage has a high potential for regional energy efficiency and **reduction of greenhouse gas emissions,**
- For residential areas solar thermal collectors have a high potential to **increase energy efficiency** of new and existing buildings,
- Solar thermal systems work very well together with a **superinsulated building envelope,**
- For passive houses and lowest-energy-houses the energy consumption for domestic water heating can even be higher than the energy consumption for space heating,
- Solar thermal systems effectively reduce the energy consumption for hot water generation and can also support space heating. Therefore it is important to examine the co-operation of solar thermal systems with energy efficient building envelopes. Especially to realize zero and nearly zero energy buildings which is targeted by the proposal for the recasted EU-Directive on the energy performance of buildings (EU-2008/0223 (COD), 13.11.2008, § 9).

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PROJECT 2009:
Solar thermal energy generation for new and existing building estates

Objectives:

- examine planning methods and actual energy generation for solar thermal collectors in Czech Republic and Austria,
- present concepts and pilot projects regarding innovative solar thermal solutions for new residential buildings and thermal retrofit measures with lowest energy consumption,
- The results should be used for education and training activities for solar planners.

Tasks:

- Compilation of relevant standards and calculation methods for active solar thermal energy generation,
- Compilation of regional statistics for energy generation from solar thermal collectors for residential building estates,
- Compilation of relevant existing training material,
- Compilation of concepts and pilot projects regarding active solar thermal energy usage for building estates and residential areas. Especially combined domestic hot water generation and space heating as well as seasonal thermal storage,
- Compilation of concepts and pilot projects regarding active solar thermal energy usage for thermal retrofit measures.