08.01 Building Heating Supply Areas 08.02 Predominant Heating Types (Edition 2005)

Overview

Types of Fuel for Generating Building Heat

On account of the close relationship between the topics covered in Maps 08.01 - "Building Heating Supply Areas" (Edition 2005) and 08.02 - "Predominant Heating Types" (Edition 2005), a common text has been prepared for both maps.

Berlin is the largest contiguous built-up conurbation in Germany. Approximately 3.4 million inhabitants live in an area of 889 km^2 (June 2004). The development of heating and heat supply to residential and commercial buildings, as well as the distribution of the various kinds of fuel, are tied to the evolution of the city and are characterized by its social structure and development history.

In the course of the industrialization period after 1875 and the dramatic population increase which this brought with it, Berlin's old city center (within the present City-Rail Circle Line) developed largely into a city of tenements. On the edge of the inner city, the housing construction companies' first settlements emerged. In the outer areas, villa colonies and garden city projects were built. Until the end of World War Two, the city's heating fuel supply relied almost exclusively on lignite and anthracite.

Post-war development was marked by large-scale reconstruction and new building projects, which initially used row construction. From the 1960s to the 1980s, large developments and satellite towns emerged in the outer areas, while the inner city's housing programs were initially characterized by demolition and construction from scratch. Starting in the mid-1970s, preservation-oriented forms of urban renewal were undertaken, primarily in Wedding and Kreuzberg (cf. Map 06.07, SenStadt 2002). The use of different fuel types for the heating of residential buildings and workplaces developed differently in East and West Berlin during this period.

West Berlin

In the **western part of Berlin**, coal was increasingly being replaced with other energy sources after the early 1970s. The choice of a substitute fuel type largely depended on local housing structures: in single-family and duplex homes in the outer areas, the primary fuel type used for heating was light fuel oil. For the heating of residential apartment buildings and workplaces, fuel types were chosen largely by proximity to heating supply networks (in the case of energy providers with pipe networks). In-plant oil-fired heating units were also common.

Until 1989, the large number of heating power plants in insular West Berlin facilitated a continuous development of district heating, which was supplied by the Berlin Electric Power Company (BEWAG). As BEWAG was traditionally focused on supplying electricity, however, optimization of its thermal technology structures has proven difficult.

East Berlin

In the **eastern part of Berlin**, heating relied almost exclusively on lignite and natural gas up to 1989 – in single-family and duplex housing areas and in multi-story old building quarters, but also in workplaces. Approx. 60 percent of the apartments in the eastern part of Berlin were provided with self-contained and/or communal coal heating in 1989; approx. 40 percent of the apartments were provided with district heat from heating plants and heating power plants. Because of usage restrictions in the former GDR, fuel oil was not made available to the heating market.

Berlin After 1989

After 1989, city development in the reunited metropolis experienced several different stages. Between 1991 and 2000, approx. 150,000 new apartments were built. Approx. 60 percent of the newly erected buildings were a part of existing larger compounds. By 1992, construction of existing tower block building

projects in the east of the city was completed. In the west, there was little activity in city development. Between 1993 and 1997, numerous major construction projects were undertaken, for example new suburbs in outer areas such as the former farmlands of Karow-Nord, and prestigious inner city projects such as Potsdamer Platz and the new government buildings. Since 1997, the number of new development projects has been declining throughout the conurbation. As a result of the decrease in city development funding, the number of new construction projects in 2003 was almost as low as in 1991. Following a boom of home building in the eastern outer areas and surrounding regions in 1998/1999, this area of development has also begun to stagnate. Nearly 80 percent of the expansive tower block developments in East Berlin, as well as many of the inner city's old building quarters, have been rehabilitated with the help of state funding (structural renovations, improved residential interiors).

Energy politics, and with them the local heat supply market, changed radically after 1989. Whereas West Berlin's insular geographical position and East Berlin's centralized control structures had previously ensured well-defined supply networks, the city's unification had a destabilizing influence on the supply of energy throughout the city. Berlin was hurriedly linked into the country's nationwide power and gas networks, and in 1997, Berlin's main energy supplier BEWAG changed from predominantly public ownership to being fully privatized. The Energy Law amendment of 1998 created new conditions for the domestic power and gas market (cf. Bundesministerium für Wirtschaft und Arbeit 2004). However, market tendencies until the end of 2003 have shown that Berlin's established energy suppliers BEWAG and GASAG continue to supply the main bulk of power, district heat and gas.

Also since 1989, the Berlin Senate has widely advanced its energy politics to respond to global climate changes and optimize the use of energy in the local generation of heat. Measures have included:

- A new bill to encourage economical as well as environmentally and socially viable energy supply and use (cf. Berlin Energiespargesetz - BEnSpG).
- Energy white paper 1990-1996 to assess the measures of the 1994 Energy Concept (cf. Energiebericht 1990-1996).
- Collation and agreement of a State Energy Program 2000-2003. This also stipulated as a public service the creation and maintenance of the Environmental Atlas Maps contained herein (cf. Landesenergieprogramm Berlin 2000-2003).
- Numerous other activities and initiatives towards energy usage reductions and energy optimization in the field of building heating (cf. in-depth reports in "Klimaschutz - Schwerpunkte in Berlin" (only in German)).

A comparison of our last survey from 1994/95 to the data collected on heating-related energy consumption in 2000 (see table 1) demonstrates vividly the progress that has been made since the introduction of state-funded and private/corporate measures in the field of building heating.

Emission-reducing measures for domestic heating have proven more effective than for industrial production sites and power plants, as is shown by the lowered emission figures.

Table 1: Proportional shares of heating types, 1994/2000

Type of heating	Proportional shares of heating types for residential and commercial spaces			
	1994		2000	
	m^2	%	m^2	%
Nightstore systems	1.910.645	1%	4.112.205	3%
District heating	51.506.422	31%	51.643.493	33%
Gas heating	35.490.232	21%	40.720.186	26%
Oil heating	48.891.625	30%	51.101.020	33%
Coal heating	27.757.262	17%	7.915.112	5%
Sum of heating area	165.556.186	100%	155.492.016	100%

Table 1: Proportional shares of heating types in residential and commercial spaces, 1994/2000

As shown in table 1, the total floor area of heated buildings has increased by 15 percent between 1994 and 2000. Residential floor area has increased by approx. 8 percent (1994: 118,255,000 m^2), and the number of apartments/houses (1994: 1,102,403) has increased by 10.2 percent. There are currently no

figures for the increase in commercial floor area that is heated from non-certified furnace plants; this affects at least 15 percent of the floor areas surveyed.

While the supply of energy, including electricity, still varied greatly between East and West Berlin in 1994, these differences had largely disappeared by 2000. This is mostly due to a dramatic increase (almost 70 percent) in the use of natural gas for heating; the increases in district heating (approx. 25 percent) and local oil-fired heating (approx. 35 percent) are significantly lower.

With approx. 4,500 residential and commercial blocks that predominantly rely on gas for heating, natural gas is the second most widely used heating source; blocks that predominantly employ oil-fired heating represent the largest share (approx. 6,700 blocks), whereas district heating ranks third (approx. 3,200 blocks).

All of the heating types that have increased in usage, particularly in the boroughs of former East Berlin, have done so at the expense of coal-fired heating. Between 1994 and 2000, the total floor area heated with coal decreased by approx. 75 percent. Today, less than 5 percent of residential and commercial spaces are heated with coal.

Distribution of the different heating types in the 12 Berlin boroughs and the changes between 1994 and 2000 are illustrated in figs. 1 and 2. Note that in 1994, oil-fired heating had a relatively low share in the outer eastern boroughs (Treptow-Köpenick, Pankow, Lichtenberg, Marzahn-Hellersdorf), whereas coal heating had a comparatively high share. By the beginning of the new decade, this trend was reversed (for further data on the current distribution of heating types see the map descriptions).

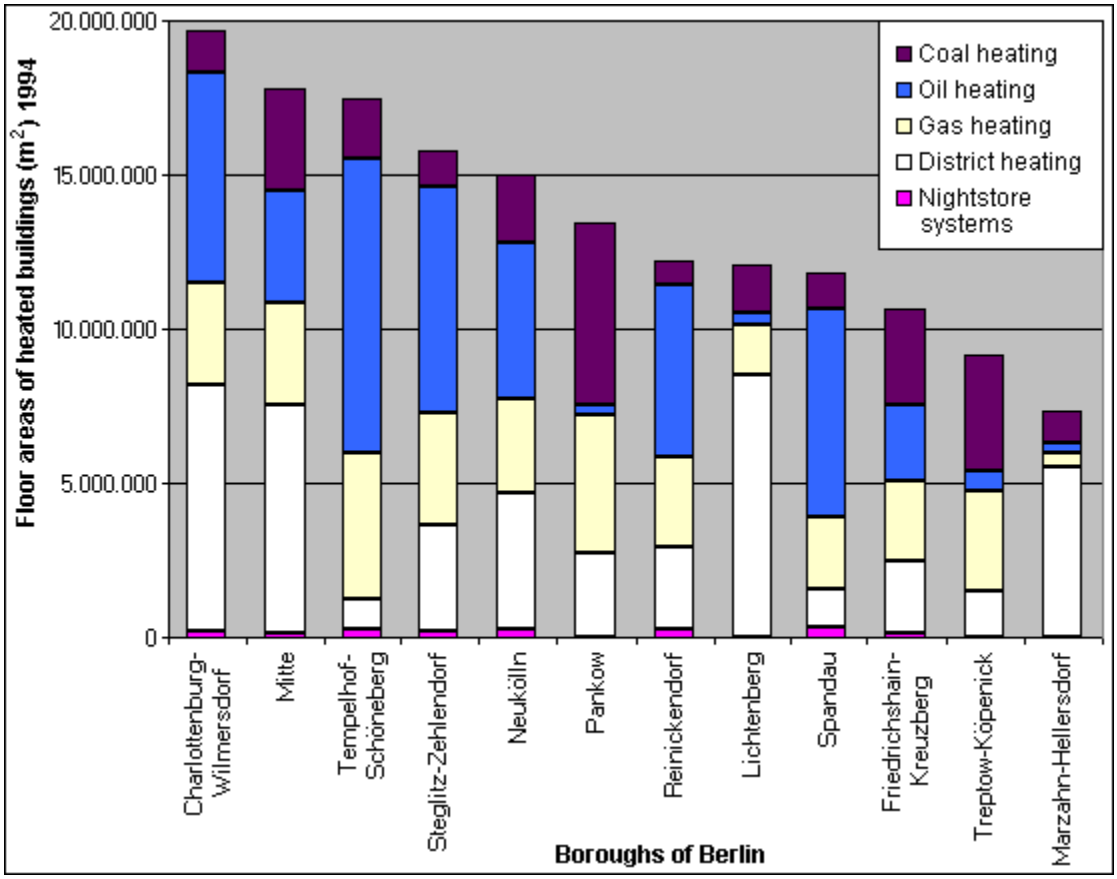

Fig. 1: Heating types in residential and commercial spaces by borough, 1994

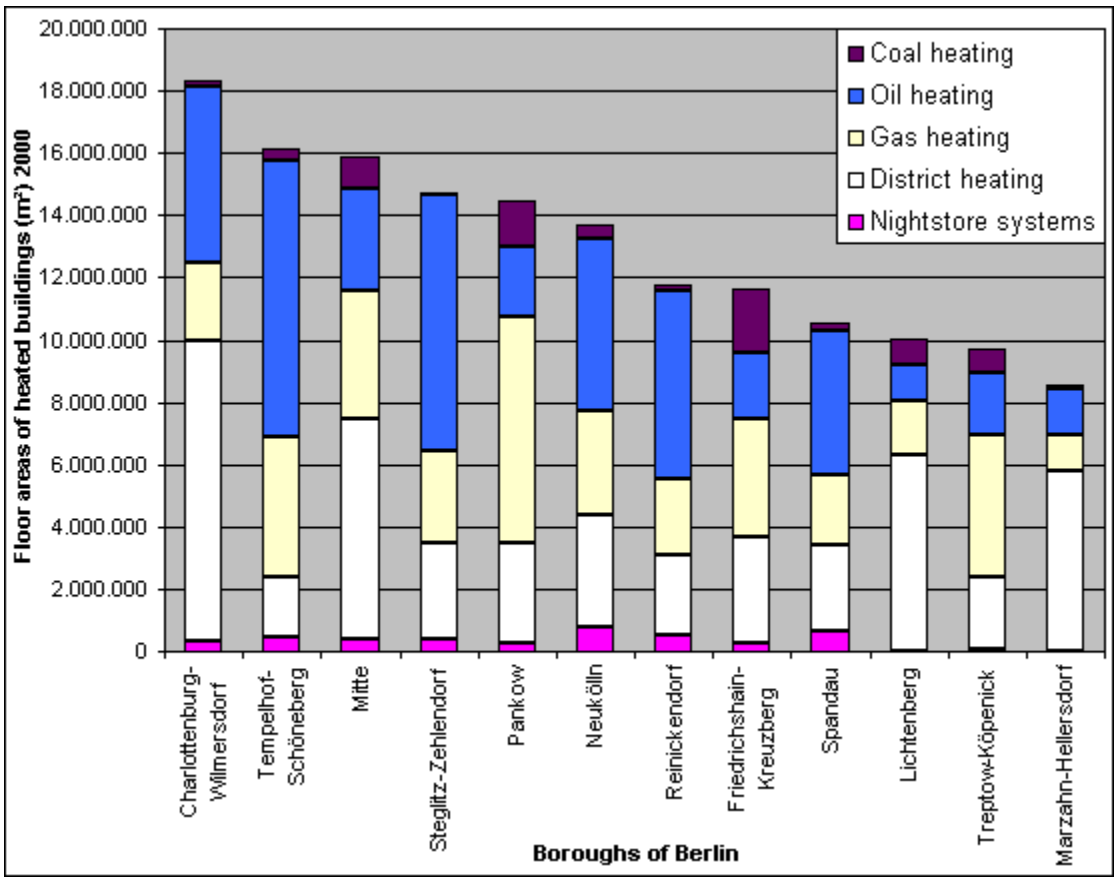

Fig. 2: Heating types in residential and commercial spaces by borough, 1999/2000

With a pipe network of more that 7,300 kilometers – the main providers being BEWAG with 1,200 kilometers and GASAG with 6,100 kilometers – Berlin has the biggest supply network of pipe-dependent energy types in Western Europe.

Fundamental changes in the supply of heating have already resulted in a significant improvement in air quality. Values for all directly emitted pollutants have decreased significantly over the past 10 years. The most drastic reduction is encountered for sulfur dioxide, which in the past was primarily emitted by power plants, industrial plants and coal furnaces. Fig. 3 illustrates the spatial distribution of SO_2 emissions.

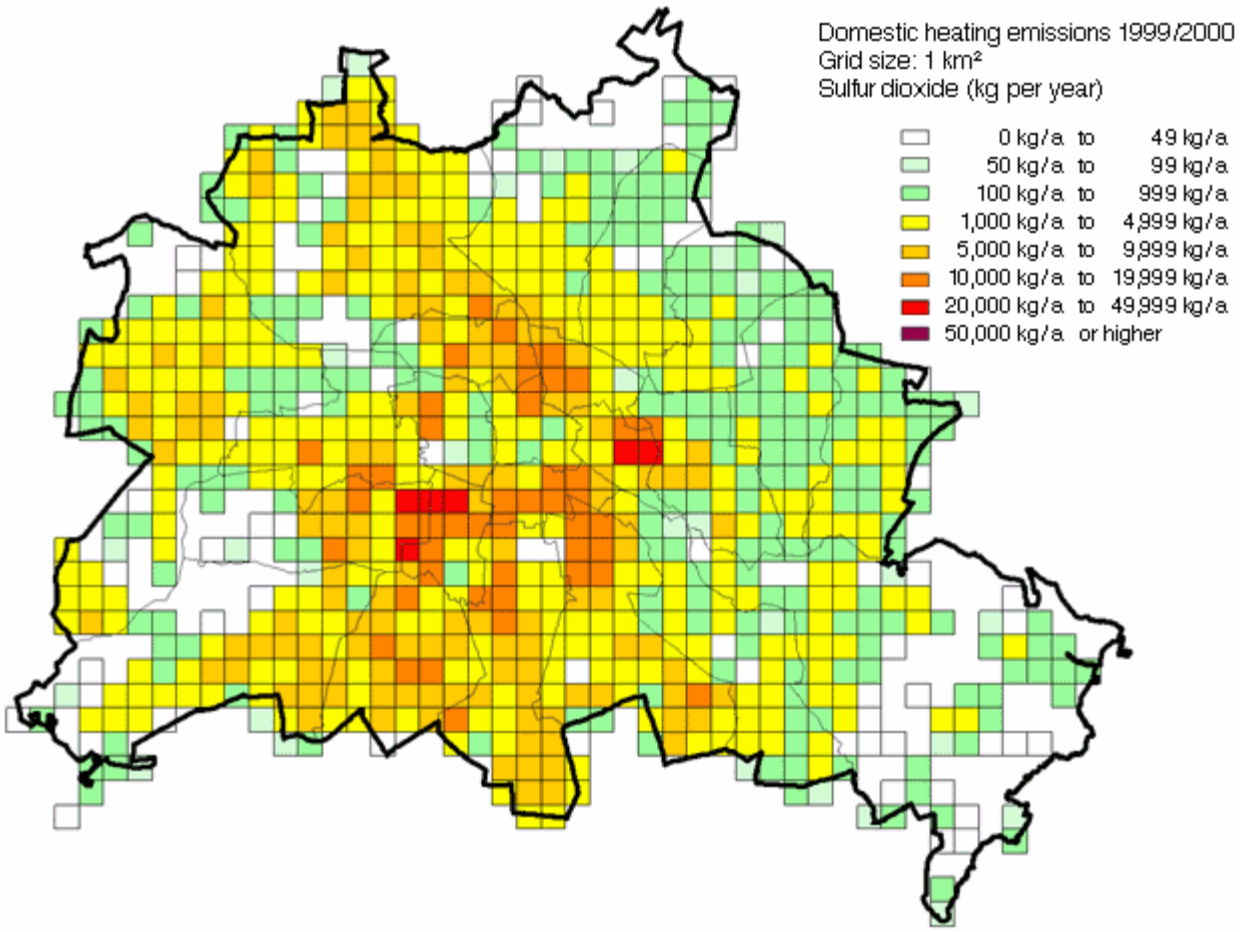

Fig. 3: Sulfur dioxide emissions resulting from domestic heating in 2000

Whereas in 1994 42 km² were recorded with SO_2 emissions above 20 t/km²/a, only 6 km² were recorded at the same emission level for 2000 (see figure 3). The highest emission levels caused by domestic heating are still to be found in the densely populated inner city boroughs, particularly Schöneberg und Friedrichshain – boroughs that also contain the most old buildings with oil and coal heating. Other densely populated boroughs such as Gropiusstadt, Märkisches Viertel, Hohenschönhausen and Marzahn, characterized by their tower block parks, do not display excessive emission levels, as these are largely heated with district heat. The emissions generated by district heating can be traced to specific heating power plants, which is shown in Map 08.02.2.

For further in-depth information, please refer to the publication accompanying the current Domestic Heating Database 2000.

Carbon Dioxide Emissions

Carbon dioxide (CO_2) has become a widely discussed topic in recent years, but it still cannot be reduced very efficiently through technical measures.

There are a number of cornerstones for implementing the governmental target of a 25 percent reduction in carbon dioxide emissions per capita by 2010; these include greater efficiency in the consumption of energy sources for heating and other purposes, as well as sensitive management of all natural resources. In December 1994, the state of Berlin adopted the **Berlin Energy Concept**. Among others, this stipulates a reduction in energy consumption for residential and commercial heating, particularly in public buildings.

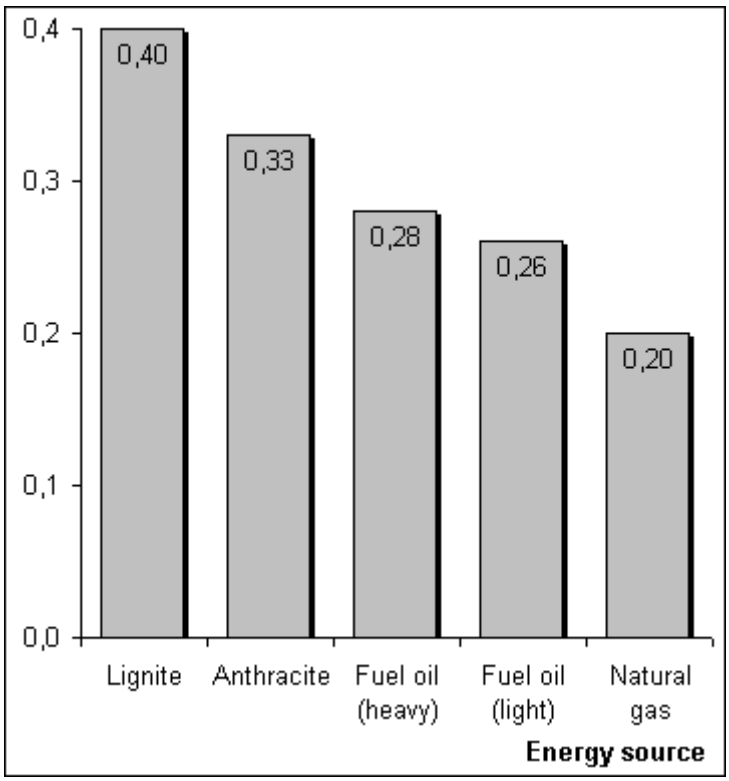

Fig. 4: CO_2 emissions (kg) per kWh of primary energy released by fuel burning (cf. MUNR 1994)

By 2000, energy-related CO_2 emission was reduced by 14.0 percent. This reduction was possible primarily due to combined heat and power (CHP), improved energy usage in buildings, and greater energy consumption efficiency in commercial applications.

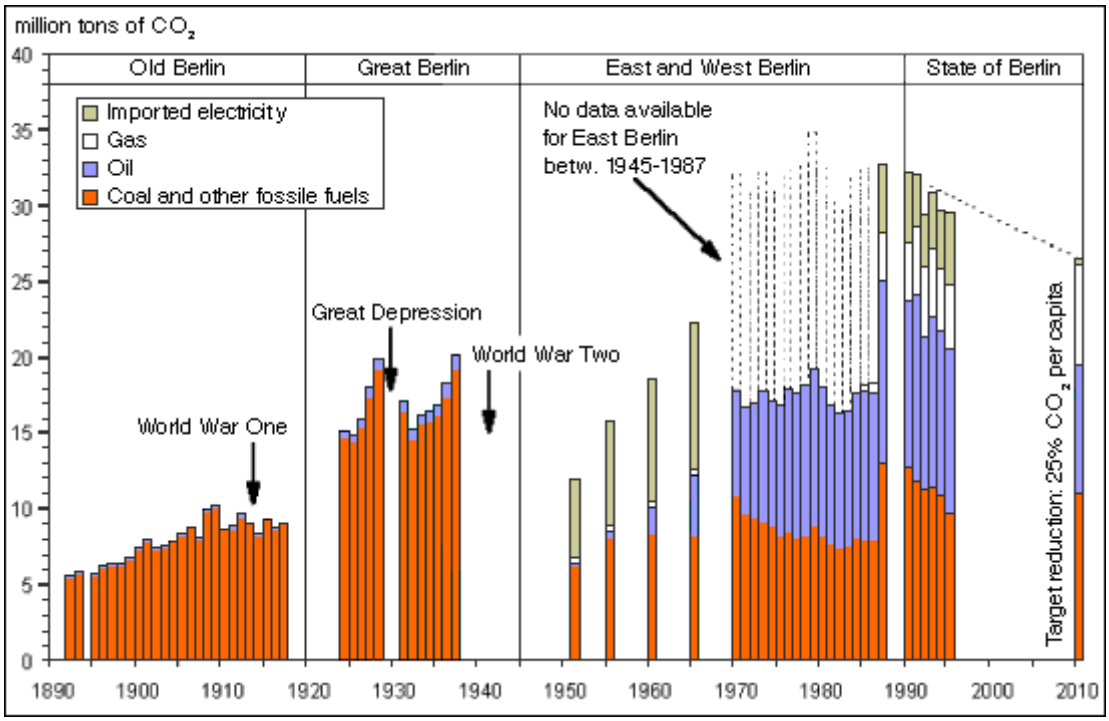

Fig. 5: CO_2 emissions in Berlin (survey by Öko-Institut)

Only once a comprehensive energy consumption review has been compiled will it be possible to assess whether Berlin's subsequent reduction in CO_2 emissions is compliant with the target figures of the State Energy Program, which stipulate a temperature-adjusted value of 25.4 million tons of CO_2.

The Berlin Energy Concept outlines an approach for the state of Berlin to autonomously reduce CO_2 emissions by 25 percent between 1990 and 2010. Emissions caused by residential buildings are a focal point; these can only be reduced significantly if the energy consumption in old buildings is thoroughly modernized. Since 1990, the state of Berlin has been exemplary in its funding support for the rehabilitation of old buildings. Between 1991 and 2001, a total of approx. 5 billion euros was allocated to a number of rehabilitation programs:

- Heating modernization program
- Tower block rehabilitation program
- Program for urban gentrification and repopulation of vacant spaces
- Program for city-wide measures
- Program for tenancy modernization
- Program for the assessment and outsourcing of thermal insulation requirements

The energy-related aspects of these programs aimed to improve the energy consumption efficiency of building shells (thermal insulation, window replacement, etc.), to improve the efficiency of heat supply plants, to replace inefficient stand-alone plants, to replace high-carbon energy sources such as coal and fuel oil with district heat (where feasible) or with efficient local heat solutions (employing e.g. natural gas), and to increase the use of renewable energies.

To date, these programs have reached more than a third of Berlin's residential spaces and half of the city's tower block parks.

Rehabilitation of tower blocks has resulted in a reduction of heat consumption for residential heating from approx. 200 kWh/m^{2}a to less than 100 kWh/m^{2}a; a similar reduction was achieved for rehabilitated brick buildings.

While there were more than 400,000 coal ovens to be found in Berlin's apartments in 1990, this number has now been reduced to approx. 80,000. District heating has increased from approx. 450,000 connections to 580,000, and modern gas heating connections from 300,000 to 460,000.

The exploitation of solar energy has evolved from a minor niche market to an accepted form of energy generation. Currently there are approx. 42,000 m^2 of solar paneling spread over 2,780 solar heat collectors and approx. 5.3 MWp ("p" for "peak output at full solar irradiation") being generated by approx. 900 photovoltaic systems. Considering that more than 12,000 GWh of electricity were available to Berlin's consumers in 2000, the power generated by solar systems is still a very small fraction of the total power supply.

While Berlin experienced an overall reduction in CO_2 emissions of 15 percent since 1990, the reduction in CO_2 emissions for residential buildings is estimated at 20 percent.

For further information on the individual programs, please refer to the State Energy Program itself or to the publication "Klimaschutz - Schwerpunkte in Berlin" (only in German).

BEWAG's 12 heating power plants are crucial to the supply of heating in the city, as are the increasing number of local furnace plants. Some of these block-based heating power plants have thermal outputs and fuel types that class them as industrial plants requiring certification, and are therefore not included in the assessment of domestic fuel consumption. In 2000, there were approx. 250 certified furnace plants. Since the environmental friendliness of the district or local heating provided by these plants depends to a large degree on the fuel used for heat generation, Map 08.02.2 shows the fuel consumption of the larger plants (those generating more than 20 MW of thermal output) in the heating market for 2000.

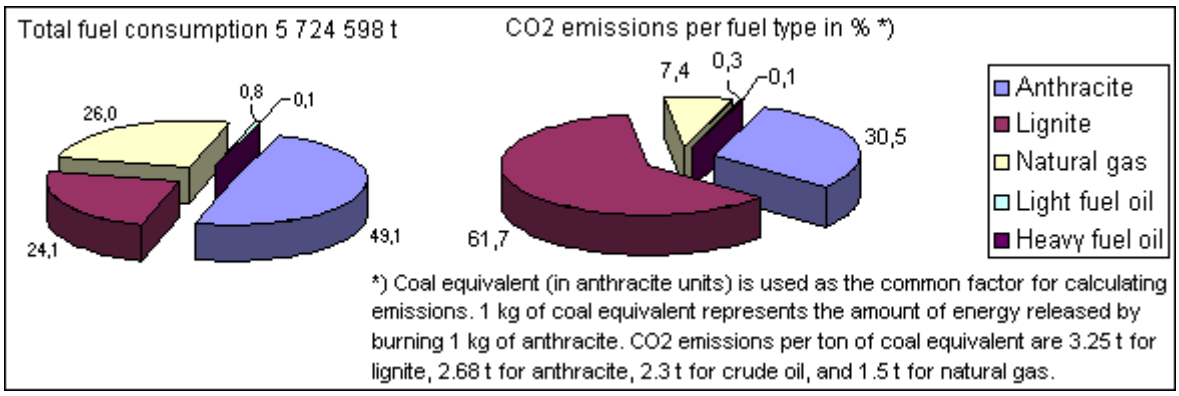

Fig. 6: Total fuel consumption and CO_2 emissions in Berlin's major heating power plants in 2000

Maps 08.01 and 08.02 show the current shares of individual energy carriers for residential and commercial heating in the built-up blocks of the city, and provide a valuable aid for the planned extension of district heat and natural gas within the supply areas. For new building areas, connection possibilities for the existing supply networks are shown.

Statistical Base

Since the unification of the divided city, residential and commercial buildings – particularly in the east – have been subject to constant change through new construction measures, renovations and shutdowns. This has entailed dramatic changes in heat supply structures all over the city. Since around 2000, both the construction of new buildings and renovations on existing buildings have decreased again to a lower, more stable level.

The base data for the maps presented in this Environmental Atlas was gathered from the data provided by the Emissionskataster Hausbrand (Emissions Database for Domestic Heating) of the Senatsverwaltung für Stadtentwicklung (Senate Department of Urban Development). This publication also describes in greater detail the surveying objectives and procedures. All data was collected in 1999/2000, updating the previous database state of 1994.

Data was collected by building. For each building, there are entries for address, number of apartments, floor areas of heated spaces, types of heating, and fuel consumption for each heating type. Addresses and heating types were updated from the 1999/2000 customer records held by Berlin's electricity, gas and district heat providers, and also the city's chimney sweep guild.

Despite the breadth of the researched base data, it was not possible to obtain complete figures in all cases, particularly commercial/industrial sites and buildings heated from local heating power plants. Self-contained sites with small floor areas, such as forest outposts, churches or excursion restaurants, were likewise not covered in full.

Methodology

The existing block- and/or lot-specific databases on housing and workplace heating have been compiled for graphical representation per block, or in individual cases per block segment. Of the approx. 26,500 statistical blocks contained in the Environmental Information System (ISU) of the Senatsverwaltung für Stadtentwicklung, all those which are predominantly built-up are included on the map (cf. Map 06.07, SenStadtUm 2002). In the case of self-contained sites located within parks, forests or other large grounds, only the corresponding block segments were researched and included in the graphical representation.

A division of results into two separate maps means there is both an overview for each energy carrier (Map 08.01) and a representation of the fuel type(s) used in each city block (Map 08.02). Map 08.02.2 shows the most significant sources of district heat. The fuel types used in residential and workplace heating are categorized into five heating types: district heat, gas, oil, coal and nightstore.

Maps 08.01.1 to **08.01.4** cover the heating types district heat, gas, oil and coal. They display the proportional shares of each fuel type for the total heated floor area of each block, provided the shares are 5 percent or greater. Buildings heated with nightstore systems are not shown separately because of their negligible overall share (1.2 percent of total heated floor areas).

Each fuel type is represented by the same color palette. Lighter shades represent less densely built-up blocks (less than 5,000 m^2 of heated floor area), indicating a smaller share of the energy carrier in the depicted area; conversely, the darker shades indicate densely populated blocks and the dominating influence of the respective fuel types shown on the four single maps (15,000 m^2 or more heated floor area).

Map 08.02 Predominant Heating Types shows the predominant type of heating for each block. The color shadings for all five fuel types (ranging from yellow for natural gas to purple for coal) indicate the varying degrees of air pollution caused by the different fuels. The effects of district heating, unfortunately, cannot be assessed directly from this map; although no emissions occur at the consumer end for any of the 35 individually-operated district heating networks, the burning of fuel may nevertheless cause significant air pollution at the point of heat generation. This is shown for selected plants on **Map 08.02.2**.

A heating type is classed as 'predominant' if its share of a block's heated floor area totals more than 40 percent and if this share is 20 percent higher than the block's next most-used fuel type. To distinguish the proportional shares between 40 percent and 100 percent, the percentages are divided into three equal levels. These are indicated by graduated shades of the heating type's primary color.

If no predominant heating type is indicated by the proportional distribution within a block and/or block segment, the dominating heating types are grouped into one of seven mixed categories. Mixed categories are distinguished by coloring and cross-hatching.

The total heated floor area within a block and/or block segment serves as the reference base for the proportional distribution of the individual heating types. The average heated floor area of each residential/commercial block is approx. 12,000 m^2. The floor area levels for each block/block segment are distinguished with a set of three symbols.

Map Description

The graphical representation of the assessed structural heating data for Berlin's residential and commercial spaces provides a useful tool for analyzing both larger-scale contiguous areas and self-contained sites.

Map 08.01 Building Heating Supply Areas

Fuel consumption in buildings greatly depends on their structural layout and geographical location. Marked differences can be noted between the city's 12 boroughs; usage of the different energy carriers varies greatly depending on the boroughs' respective locations within the city (cf. fig. 2).

Map **08.01.1 District Heating Supply Areas** reflects very clearly the local proximity of heating plants and heating power plants to their respective supply areas. The largest share of district heating in Berlin is provided by BEWAG, with a network spanning approx. 1,200 km. The great majority of the 7,260 blocks with access to a district heating network also make use of this heating option (more than 60 percent). In newly developed and existing outskirt residential areas such as Hohenschönhausen, Marzahn or Märkisches Viertel, many large housing estates are supplied exclusively with district heat. Altogether, the map demonstrates Berlin's leading position in Europe for the supply of district heating. Since 1995, many of the potential candidates for district heat connection – particularly coal-heated old buildings bordering existing district-heat-supplied areas – have been integrated into the networks.

Map **08.01.2 Gas Heating Supply Areas** shows the finely meshed distribution of the gas pipe network over the entire Berlin conurbation. In contrast to the 1994 survey, the proportional shares of gas heating within the respective statistical blocks are no longer just between 10 and 40 percent. As well as in the areas that were already committed to gas heating in 1994, gas has also become the primary heating energy carrier in large areas of Kreuzberg, Neukölln, Friedrichshain, Prenzlauer Berg (cf. fig. 8), southern Pankow, and to a lesser degree Köpenick and Treptow. Isolated administration, service provision and production sites all over Berlin are also taking advantage of the gas network. As is the case with district heat, most of the new gas connections have been introduced in blocks that previously relied on coal for their heat supply.

Before the unification of the two city halves but also as late as 1994, there was only very little oil-fired building heating to be found in the eastern part of Berlin, and in virtually no block was fuel oil the predominant energy carrier. Map **08.01.3 Oil Heating Supply Areas** (supply situation 1999/2000), however, indicates that today there are numerous blocks that use fuel oil for more than 80 percent of their heating requirements, particularly in those areas of eastern Berlin that do not have access to the pipe networks. The geographical spread shows no clearly defined centers, instead there is a narrow stretch of fuel oil usage along the eastern city perimeter. The increase in oil heating that was to be

expected after 1994 can largely be traced to the organized replacement of coal-fired hot-water boilers (cf. fig. 7).

In the eastern part of the inner city, on the other hand, there are virtually no blocks that rely on fuel oil for heating.

Supply structures in the western part of the city have undergone much less change. In the suburban housing areas on the city outskirts, fuel oil continues to dominate as the primary heating source. The fuel oil share of the total heated floor area in such blocks is often well above 60 percent.

Major shifts towards pipe-dependent heating systems are to be found in a number of inner city areas, for example, south of Bismarckstrasse in Charlottenburg.

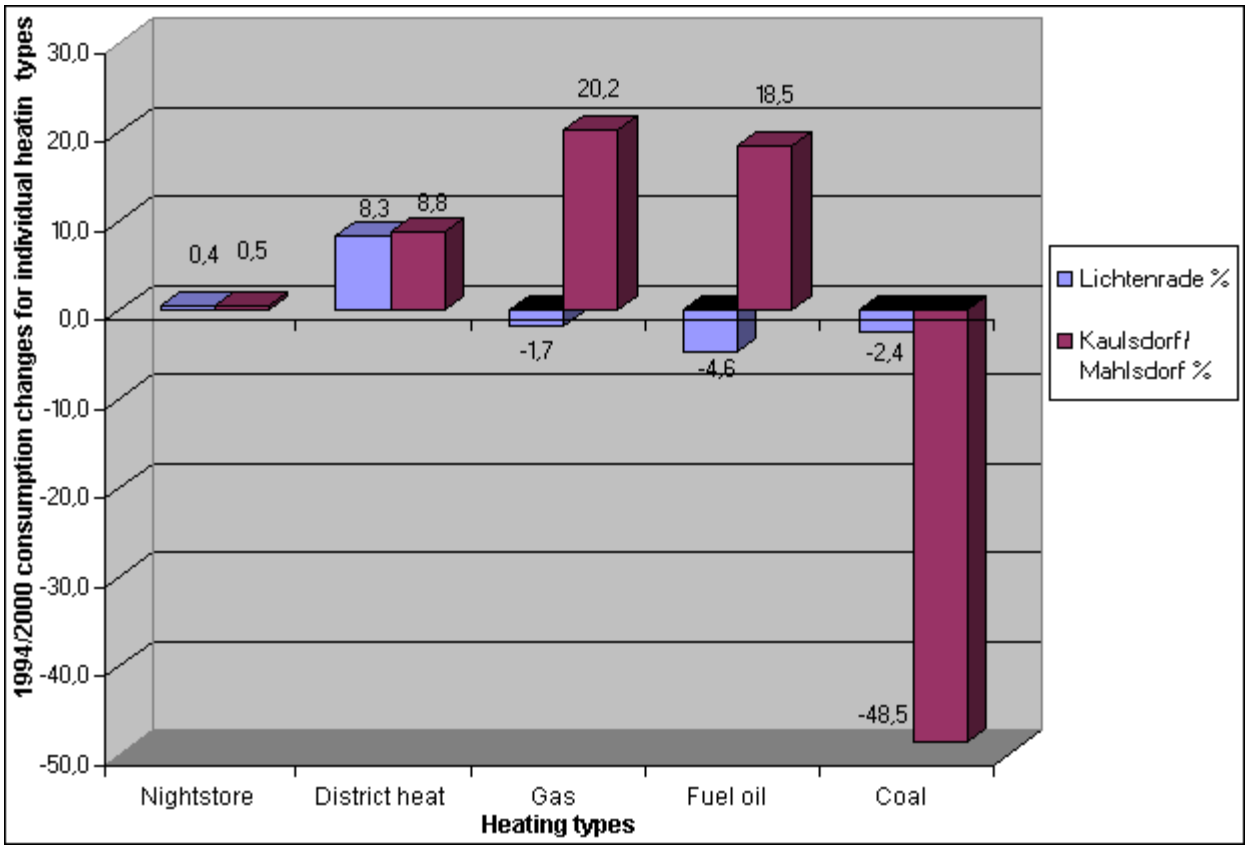

Fig. 7: 1994/2000 consumption changes for individual heating types; blocks containing single-family and duplex houses, Lichtenrade and Kaulsdorf/Mahlsdorf (predominantly residential blocks with "garden style" architecture)

Map **08.01.4 Gas Heating Supply Areas** very clearly demonstrates the dramatic 70 percent decrease in coal heating in housing and workplace areas since 1994 (cf. figs. 7 and 8). Currently, only 5 percent of all spaces are heated with coal; of these, most are in Prenzlauer Berg and Friedrichshain, and to a lesser degree in the old building quarters of Kreuzberg. Whereas 1.6 million tons of lignite were still being used for heating in 1991, this value sank down to 600,000 tons in 1994 and by 1999/2000 reached a comparatively low 90,000 tons.

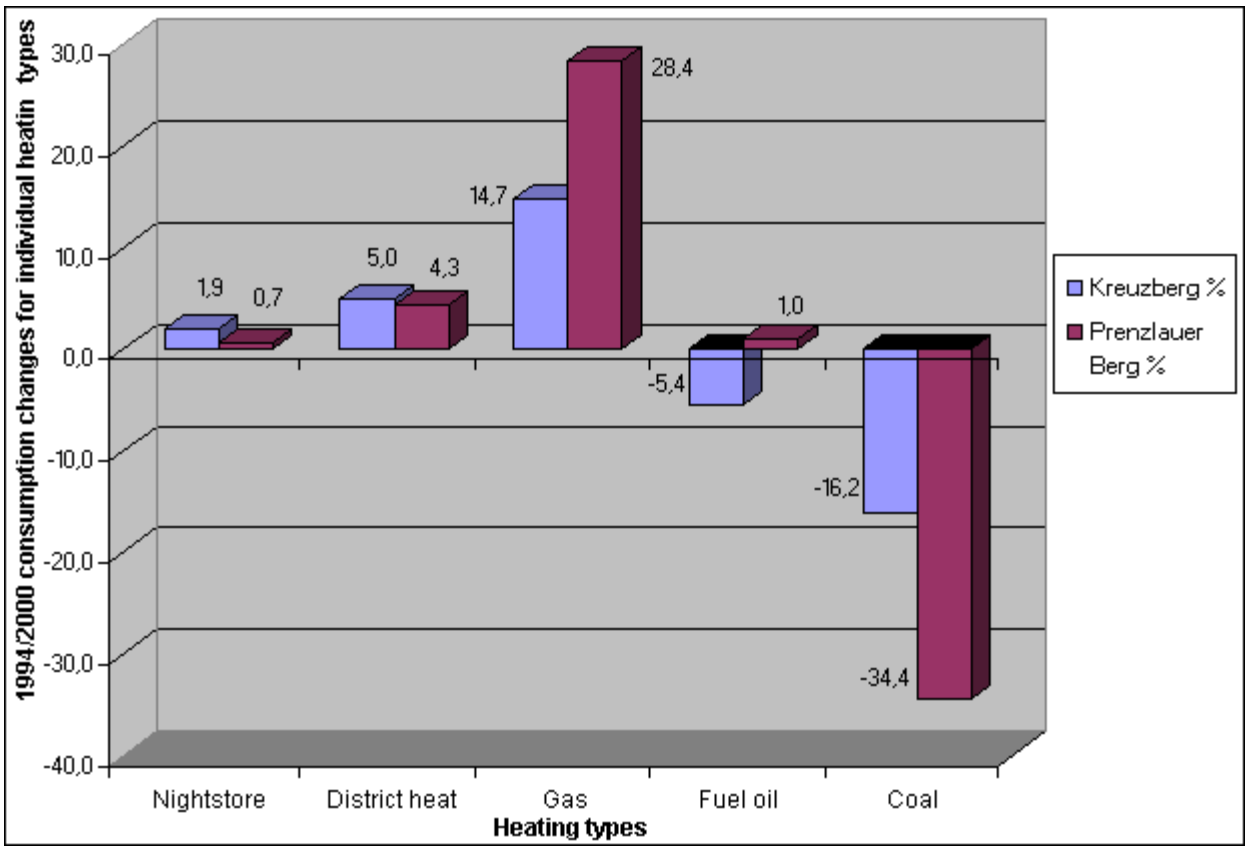

Fig. 8: 1994/2000 consumption changes for individual heating types; blocks containing Wilhelminian-period buildings, Kreuzberg and Prenzlauer Berg

Note that this graphical representation does not show that more than 70 percent of the fuel used by BEWAG's major district heating power plants continues to be anthracite, as well as lignite (e.g., the Klingenberg heating power plant) (cf. Map 08.02.2).

Map 08.02 Predominant Heating Types

Map 08.02.1 Supply Shares of Individual Energy Carriers

As the predominant heating types represented on this map demonstrate, the heating structures within the two city halves still differ greatly. In the west, particularly the areas outside of the inner City-Rail Circle Line, fuel oil has a long tradition of being the dominant fuel type for building heating.

In the inner city, district heating is generally the primary heating source. Natural gas is a dominating source only in parts of Kreuzberg and Neukölln; however, as mentioned above (cf. 08.01.2 Gas Heating Supply Areas), its use has become wide-spread throughout Berlin.

In the eastern parts of the city, the dominating role of coal heating that could still be noted for large areas in 1994 has diminished almost completely. It has been replaced foremostly with natural gas and fuel oil, the latter being used particularly in areas outside of the inner city. The dramatic increase in gas heating recorded since 1994 – almost 70 percent – is caused primarily by increased usage in the eastern boroughs. Thanks to the established supply networks, district heat has also been a primary source for heating in these areas, even before 1989. In the modern development projects of Marzahn and Hellersdorf, district heat in fact has a supply share of 100 percent.

In some outskirt areas such as Biesdorf, Mahlsdorf and Rahnsdorf, mixed supply types dominate, e.g., gas plus fuel oil. As with another frequently encountered mixed supply type – district heat plus fuel oil – this is largely a result of replacing coal as an energy source. In the western part, mixed supply with gas and oil is dominant in areas with contiguous block development, for instance Schöneberg, Tiergarten, Wedding, as well as Spandau and Reinickendorf.

With regard to future developments in the use of heating energy, it is the mixed supply areas of Berlin that are of particular interest – as are those where different supply structures are directly adjacent. Due

to the spatial proximities in these areas, there are great opportunities to further develop the use of district heat and gas.

Map 08.02.2 Fuel Use of Major Heating Plants and Heating Power Plants

Map **08.02.2 Fuel Use of Major Heating Plants and Heating Power Plants** demonstrates that even in Berlin's power plants, fuel use varies greatly. The predominant energy sources used in the city's 35 certified plants are anthracite (50 percent), lignite and natural gas (25 percent each). Fuel use ranges from 100 percent natural gas (e.g., the Charlottenburg heating plant) to 90 percent lignite (e.g., Klingenberg heating power plant) (cf. fig. 6).

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