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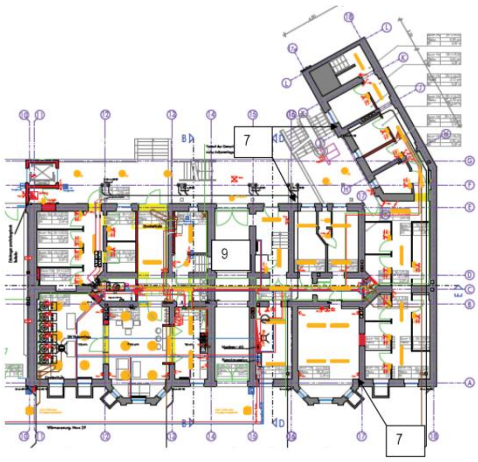
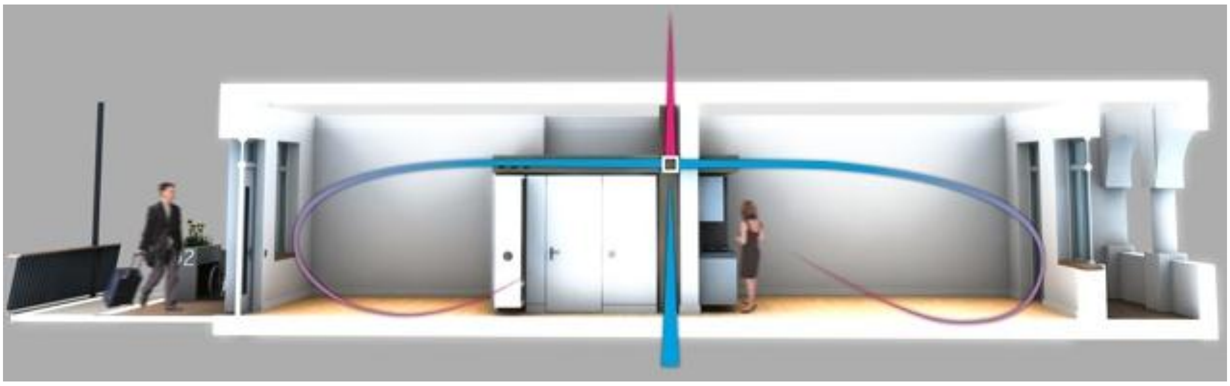
Energy efficiency and renewable energies in urban quarters
Best practice examples from Brandenburg Land





Published by: Industrie- und Handelskammer Potsdam

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument).

Baltic Sea Region
Programme 2007–2013

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26.09.2011

Foreword

The INTERREG IV B project "URB Energy" deals with the development of integrated urban development concepts for energy-efficient modernisation of urban quarters in the Baltic Sea region. Implementation plans are being developed at the quarter level and partially implemented in the scope of work package 4 "Energy Supply". Brandenburg Land, represented by its project partner, the Potsdam Chamber of Commerce and Industry (IHK Potsdam) has taken on the task of identifying already implemented solutions for the use of renewable energies in residential buildings as part of the Energy and Technology Initiative (ETI). These best practice examples are intended to give our partners in Eastern European partners countries stimuli and approaches for optimal integration of low greenhouse gas energy supply in renovated buildings. In the process of selecting the examples, particular focus was given, for one, to a transferable starting situation. Moreover, the selection of a specific range of different properties was intended to take into account the differentiated building typologies in an urban setting. In addition, in particular, solutions already implemented in an urban quarter or building complex and could thus serve as a basis for planning in quarters were specifically sought out.
IHK Potsdam hired the Schneider/Engler Energieplanung [Energy Planning] engineering firm to carry out the study. After viewing a wide range of different properties, it was decided that four examples would be utilised and separately elaborated:
Three of these properties are located in Brandenburg Land and present the way of integrating renewable energy sources in a modernised building complex:

Potsdam: Use of solar-thermal systems in combination with district heating and energy efficiency improvements of the building envelope.

Hennigsdorf: Energy upgrading of the building stock in combination with district heating from renewable energy sources

Prenzlau: Energy modernisation and supply of district heating from renewable energy sources to listed structures.

The fourth example from the Federal State of Saxony-Anhalt presents a unique approach in the city of Wernigerode. Here, first and foremost, low-threshold investment measures, such as flow balancing, were employed to produce a significant improvement in energy efficiency.

ETI is a project carried out by the Ministry of Economy and European Affairs and IHK Potsdam as the implementing organisation for Brandenburg Land's energy strategy. As such, energy-efficient urban redevelopment, as anchored in the energy strategy, became a particular concern. In this process, the aim is to develop a pillar to support the safeguarding of employment in the building trade, crafts and manufacturing as well as in the private and public service sector, thereby also tapping into regional growth potential.

This brochure contains compact presentations of the identified best practice examples and should serve, first and foremost as a stimulus for implementing energy efficiency measures and employing renewable energies in residential buildings.

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Introduction

The idea behind URB.Energy is to realise the considerable energy savings and greenhouse gas reduction potential in buildings. In this framework, the situation in Eastern Europe is particularly series since large portions of the flat stock are made up of structures built during the Soviet era using large panel construction, a method which exhibits considerable deficits in terms of the building fabric and energy efficiency. Against the backdrop of rising energy costs, this leads to a disproportionately high placed on tenants due to operating costs. As a result, rents can hardly be raised, such that flat construction companies have only very limited resources at their disposal to undertake necessary renovation measures. This is complicated by differentiated residential property ownership situations: as such, it is possible that the property, building envelope and individual flats are all owned by different parties. Competing interests can thus render it quite difficult to identify approaches for complex building energy modernisation.

The approach taken at URB.Energy involves facing this challenge through the use of urban development concepts implemented at the quarter level. A holistic view of urban quarters in the scope of integrated urban development makes it possible to deal proactively with the complex issues raised by energy modernisation. In this endeavour, communication amongst the various stakeholders in the various spheres of action is of central importance, thus creating a point of departure for the development of a sustainable and participative planning process.

In this endeavour, the project partners from Brandenburg Land, the Ministry of Infrastructure and Agriculture (German: MIL) and the Potsdam Chamber of Commerce and Industry assumed the task of identifying and development measures and methods to create approaches to be implemented by the Eastern European partners. MIL took on this role for the area of urban development whilst IHK Potsdam mainly concerned itself with energy supply. In this scope, solutions involving the use of renewable energies at the urban quarter level were the focus of the studies. To this end, projects were identified, which, developing on a fundamental urban development approach, realised measures in urban quarters. The integration of renewable energies in the supply of district heating for energy-modernised quarters was analysed from a technical and comparative perspective. In order to enable implementation in Eastern Europe, care was taken to take up comparable building structures and indicate their basic energy situation in terms of building classification. The focus here was placed less on a consideration of the organisational planning process, with priority given to the realisation of technical options implemented across urban quarters: community heat distribution systems (local and district heating grids), decentralised, small-scale heat generation using solar collectors on various roofs to contribute to common household and domestic water heating, district heat generation with centralised process heat provision from combined heat and power produced by a small biomass heating power plant, low-threshold investment measures to optimise energy management of older boiler systems and pipe systems (flow balancing).

Evaluation methodology

There are many different technology options to generate heat in the building sector. Starting with the energy medium (heating oil, natural gas, biomass...) to energy provision (boiler systems for low temperature, condensing technology, heat pumps...) all the way to energy distribution (higher level: district and local heating, building specific: one pipe and two pipe systems). In addition, as a matter of principle, the options with regard to the choice of using a fuel or environmental heat (solar radiation, water, geothermal energy...) are open. In addition, there is the possibility optimise the energy efficiency of a building to a such an extent that separate energy production is no longer necessary (passive building).

Determining which technology can be optimally implemented depends on a number of factors (existing building, new construction, existing heating technology, location with regard to the availability of environmental heat, etc.). In order to identify the best practice studies described herein, a decision matrix with the following parameters was used:

- The project must be implemented in the context of a quarter
- Renewable energies are used completely or partially to generate energy
- This is a modernisation project in an existing building (no new buildings)
- The building structure exists in the present or a similar form in the target regions of Eastern Europe
- A significant decrease in primary energy consumption was achieved in the scope of the project

A selection was made from amongst the familiar projects based on these four questions. The search matrix narrowed the field of the available projects to such an extent that a choice was only made in a small number of cases.
For the purpose of verifying the search matrix for the concrete project, energy consultants were charged with, on the one hand, providing support in terms of definitions (e.g. what are renewable energies?) and, on the other, conducting an in situ study.

<u>Definition of individual search matrix parameters:</u>

It was indispensable to place certain concepts in a clear, definition-linked context. This particularly applies to the terms "quarter" and "renewable energies". The decision to use definitions from the legal context and/or subsidisation policy was made owing to the fact that it is on this basis that crucial investment funds are mobilised. Moreover, it is assumed that successful German funding instruments will also be used abroad, as has already occurred in the case of the Renewable Energies Act [German: EEG] feed-in tariff.
Quarter: "A quarter is made up of several spatially interlinked private and/or public buildings including public infrastructure and corresponding to an area inferior to an urban district." (KfW, 2010)
Renewable energies: "[…] hydroelectric power including wave, tidal and salt gradients and current power, wind energy, solar radiation energy, geothermal energy, energy from biomass including biogas, biomethane, landfill gas and septic tank gas as well as from the biodegradable portion of household and industrial waste [...] (EEG [Renewable Energies Act] 2012 §3.3, 2011) "[...], heat obtained from the ground (geothermal power), heat obtained from air or water and rendered technically useable with the exception of waste heat (environmental heat), heat obtained through the use of solar radiation to provide for heating power needs and rendered technically useable (solar radiation energy), heat generated from solid, liquid and gaseous biomass.

The definition is made according to the aggregate state when the biomass enters the heat generating equipment. Only the following sources of energy are recognised as biomass under this act: biomass as defined by the Biomass Ordinance (German: Biomasseverordnung) in the version valid through 31 December 2011, biodegradable components of household and industrial waste, landfill gas, sewage gas, sewage sludge as defined by the Sewage Sludge Ordinance (German: Klärschlammverordnung) [...] vegetable oil esters and cooling obtained from the ground or water and rendered technically useable or cooling obtained from heat as per items 1 through 4 and rendered technically useable (cooling from renewable energies)." (EEWärmeG (Act on Renewable Energies in the Heat Sector) §2, 2008). Further substitution measures pursuant to §7 of the Act on Renewable Energies in the Heat Sector, 2008.

<u>Selection process:</u>

In order to generate an overview of existing projects in Brandenburg, at the start of the project, a working meeting was held with the project working group (ARGE) of the MIL and the BBU (Federation of Berlin/Brandenburg Housing Companies) in its capacity as functional representative of the project's management.

All the examples listed here were defined during this meeting using the matrix. In addition, it was decided that at least one example with low-threshold investment measures should be included in order to show that a significant improvement can be achieved in terms of energy efficiency even when using comparatively limited funds. Since no suitable example of this, implemented in the context of an urban quarter, existed in Brandenburg, the decision was made to go with the excellently documented plan in the City of Wernigerode in Saxony-Anhalt.

The other projects were analysed by englerschneider energieplanung in in-situ studies. In the course of their investigation, the example of the city of Guben, which, whilst it does have an excellent analysis tool for heat consumption in the form of an energy register, nonetheless did not meet the requirements for using renewable energies.

On the following pages, the selected examples are presented in depth. On the first presentation page of each example, information is provided about the energy status of the building prior to implementing the energy enhancement measures with the respective results achieved being shown on the last page of each example.

WP 4 Energy Supply

Best practice

Use of solar-thermal systems in combination with district heating and energy efficiency improvements of the building envelope.

***Figure 1**: Grünstraße solar heating system (source: Parabel Energiesysteme GmbH)*

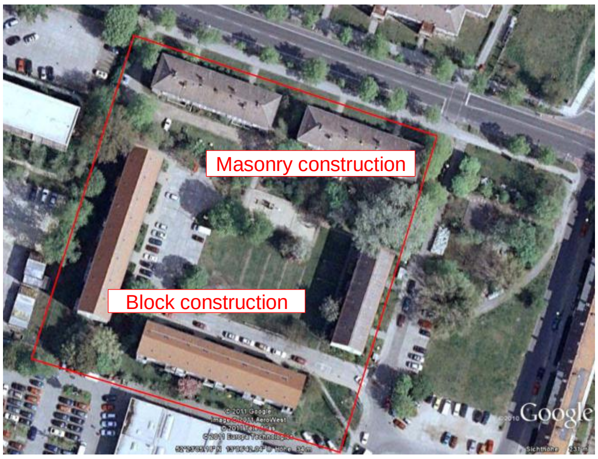


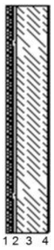
***Figure 2**: Aerial view (source: google earth)*

General information

Address:	Grünstraße 5 / Großbeerenstraße 144 in 14482 Potsdam
Contracting party:	Pro Potsdam
Building type:	Multi-family dwelling quarter (Block and masonry construction)
Primary energy source:	District heating (Energie und Wasser Potsdam GmbH)
Habitable area:	5,206 m^2
Residential units:	100
Year built:	1955 masonry construction, 1965 block construction
Implementation:	2007
Spec. heating requirements:	Block construction 140 kWh/m^2a
Masonry construction	160 kWh/m^2a
Total final energy consumption:	approx. 1,100 MWh/a

Standardised component structures prior to modernisation

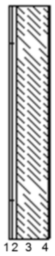
Floor against cellar/unheated room

Current state	Cellar ceiling		U value: 0.97 W/m^2K
	**U value = 0.97 W/m^2K**	Layer thickness s (cm)	Heat transfer coefficient λ (W/mK)
	Component structure: Layering from the inside out		
	1 Cement screed	4.50	1.400
	2 Wood wool panels	3.00	0.065
	3 Hollow ceiling	21.00	1.200
	4 Plaster made of lime stucco, plaster, anhydrite and calcium anhydrite	1.50	0.700
	Total thickness:	30.0 cm	

Window (to the outside)

Current state	Double pane glass (U: 2.80) – plastic frame (U: 2,80)	U value: 2.93 W/m^2K
	**U value = 2.93 W/m^2K** Size: 1.00 m^2 (1.00 m x 1.00 m) Glass: Double pane insulating glass (percentage: 67.2 %; U value: 2.80 W/m^2K) Frame: Plastic frame (percentage: 32.8 %; U value: 2.80 W/m^2K) Edge bond: aluminium (length 3.3 m; Psi value: 0.04 W/mK)	

Top storey ceiling (to the unheated roof)

Current state	Top storey ceiling		U value: 1.40 W/m^2K
	**U value = 1.40 W/m^2K**	Layer thickness s (cm)	Heat transfer coefficient λ (W/mK)
	Component structure: Layering from the inside out		
	1 Fibreboards	2.50	0.150
	2 Top concrete	3.00	2.200
	3 Hollow ceiling	21.00	1.200
	4 Plaster made of lime stucco, plaster, anhydrite and calcium anhydrite	1.50	0.700
	Total thickness:	28.00 cm	

Wall against outside air

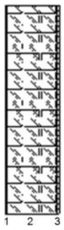
Current state	Outer wall masonry		U value: 1.25 W/m^2K
	**U value = 1.25 W/m^2K**	Layer thickness s (cm)	Heat transfer coefficient λ (W/mK)
	Component structure: Layering from the inside out		
	1 Interior plaster	1.50	0.700
	2 Sold brick, Honeycomb brick, hollow brick (1600 kg/m^2)	38.00	0.680
	3 External plaster	2.00	0.380
	Total thickness:	41.50 cm	
Current state	Outer wall precast concrete		U value: 1.23 W/m^2K
	**U value = 1.23 W/m^2K**	Layer thickness s (cm)	Heat transfer coefficient λ (W/mK)
	Component structure: Layering from the inside out		
	1 Precast concrete (single-layer panel, no fines concrete)	27.00	0.420
	Total thickness:	27.00 cm	

Table 1

Measures

The heat insulation was to go at least 30 % below the applicable EnEV (Energy Conservation Ordinance) of 2004. Pro Potsdam's objective is to take on a leading role through measures of this type in the area of energy efficiency in Potsdam.

The following measures were taken to this end:

1. Insulation of the outer wall
2. Insulation of the top storey ceiling
3. Insulation of the cellar ceiling
4. New windows
5. Renovation of the heating system complete with direct supply of district heating from CHP
6. Setup of a solar heating system to support hot water with 30% coverage, and heating with the following specifications:

Net collector size:	126 m²
Spec. collector area per RU:	1.3 m²/ WE
Solar energy station:	SES 120 FW
Buffer tank:	3,000 l
Hot water tank:	500 l
Spec. buffer volume:	28 l/m² collector area

Figure 3: *left hot water tank,*
right district heating connection station
(Source: Parabel Energieysteme GmbH)

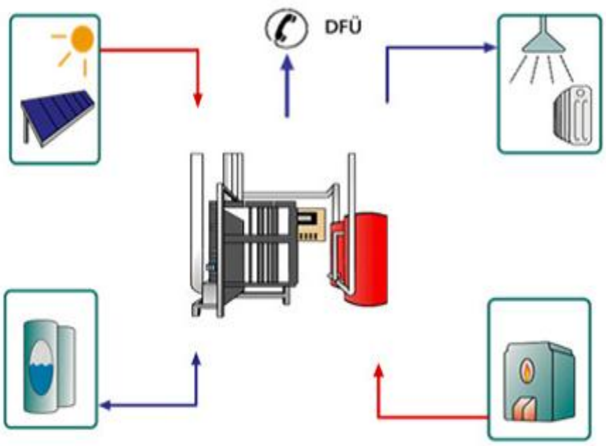
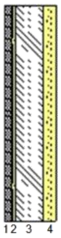


Figure 4: *Conceptual drawing of system components*
Source: Parabel Energieysteme GmbH)

Standardised component structures after modernisation

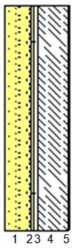
Floor against cellar/unheated room

Current state	Cellar ceiling		U value: 0.29 W/m²K
	**U value = 0.97 W/m²K** Component structure: Layering from the inside out 1 Cement screed 2 Wood wool panels 3 Hollow ceiling 4 Insulation WLG 040 Total thickness:	Layer thickness s (cm) 4.50 3.00 21.00 10.0 38.5 cm	Heat transfer coefficient λ (W/mK) 1.400 0.065 1.200 0.040

Window (to the outside)

Current state	Double pane glass (U: 1.10) – plastic frame, 4 chambers (U: 1,50)	U value = 1.23 W/m²K
	**U value = 1.10 W/m²K** Size: 1.00 m² (1.00 m x 1.00 m) Glass: Double pane insulated glass (percentage: 67.2 %; U value: 1.10 W/m²K; g value: 0.6) Frame: Plastic frame, 4 chambers (percentage: 32.8 %; U value: 1.50 W/m²K) Edge bond: aluminium (length 3.3 m; Psi value: 0.00 W/mK)	

Top storey ceiling (to the unheated roof)

Current state	Top storey ceiling		U value: 1.40 W/m²K
	**U value = 1.40 W/m²K** Component structure: Layering from the inside out 1 Fibreboards 2 Top concrete 3 Hollow ceiling 4 Plaster made of lime stucco, plaster, anhydrite and calcium anhydrite Total thickness:	Layer thickness s (cm) 2.50 3.00 21.00 1.50 28.00 cm	Heat transfer coefficient λ (W/mK) 0.150 2.200 1.200 0.700

Wall against outside air

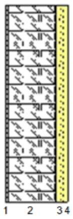
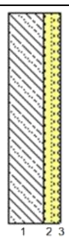
Current state	Outer wall masonry		U value: 1.25 W/m²K
	**U value = 1.25 W/m²K** Component structure: Layering from the inside out 1 Interior plaster 2 Sold brick, Honeycomb brick, hollow brick (1600 kg/m²) 3 External plaster Total thickness:	Layer thickness s (cm) 1.50 38.00 2.00 41.50 cm	Heat transfer coefficient λ (W/mK) 0.700 0.680 0.380
Current state	Outer wall precast concrete		U value: 1.23 W/m²K
	**U value = 1.23 W/m²K** Component structure: Layering from the inside out 1 Precast concrete (single-layer panel, no fines concrete) Total thickness:	Layer thickness s (cm) 27.00 27.00 cm	Heat transfer coefficient λ (W/mK) 0.420

Table 2

Detailed description of measures / equipment

The quarter located in Grünstraße/Großbeerenstraße is characterised by two different building types (see Figure 2). In order to achieve a uniform need for thermal heat and hot water for both types of buildings, the first step carried out was to take stock of the building envelope (see Table 1) and equipment for the purpose of energy balancing of the building stock. The result of this balancing was a specific need for thermal heat of 160 and 140 kWh/m²a, respectively. The goal here was to reduce this value falling below the then current Energy Conservation Ordinance of 2007 30% through efficiency optimisation measures.

By achieving the target specifications for a "KfW Energy Savings Building 60" as per EnEV 2004, it was possible to take advantage of a low-interest loan and subsidies of 10 % for energy modernisation in the scope of the KfW's energy modernisation programme.

First off, based on the improved energy efficiency building envelope (see Table 2), new parameters were determined to provide concrete interpretation of the heating system to be optimised. Due to the considerably decreased heat requirements (approx. 55%), yet only slightly different final energy required to satisfy hot water requirements, as part of the equipment optimisation process, a combination of district heating and solar thermal energy was given preference for the purpose of supporting hot water and heating. In order to take advantage of the solar thermal heating to maximise the degree of use over the year as a whole, it was decided to go with a system solution by Parabel Energiesysteme GmbH. In terms of solar thermal heating consumption, the advantage of this system solution lies in the use of solar thermal energy prior to storage in buffer vessels. In parallel, the entire thermal heat and hot water distribution system was adapted, new storage tanks were incorporated, the system was flow-balanced and enhanced with optimised pumps (see Figure 3).

The solar thermal heating manager Juri MAXX from Parabel Energiesysteme GmbH is a standardised and completely pre-assembled hydraulic station which, similar to the domestic connection stations for district heating, is used for the entire thermal energy management process for multiple family dwellings. The Juri MAXX features an integrated system regulator which enables optimum efficiency. This system combines solar thermal heating and district heating into an energy system with two heat generators and uses solar thermal heat to heat domestic water and support heating. It uses solar thermal energy to maximise the degree of use over the entire year (see Figure 4).

With most large solar heating systems, the solar thermal energy is first stored in buffer tanks and in a subsequent phase used for, e.g. heating domestic water. The Juri works according to another principle: Use before storage. The module for connecting to the solar circuit distributes, depending on temperature differences, the solar thermal energy preferentially either to domestic water or the heating system. Only when the heat generated cannot be used immediately are the buffer tanks filled.
This is the case for instance when a sufficient quantity of hot domestic water is kept available, no water is taken from the tap and thermal heat is not required on Summer days.
One decisive advantage of this principle: The buffer tanks can generally be smaller in size, and the associated heat losses decrease accordingly. The solar heating system goes into collector mode after the switch-on temperature on the collector's field sensor is reached. This temperature is thirty one degrees. This means that after heating the solar liquid, it is immediately possible to use the solar thermal energy by heating the water taps. This is done using the first heat exchanges in the solar module. Moreover, upon reaching sufficiently high temperatures, when needed, the functions of solar domestic hot water tank charging, circulation loss compensation and solar legionnella disinfection can be performed here. To do this, a solar over-temperature with a difference of five Kelvin vis-à-vis the lower hot water tank temperature. Solar heating support is provided via the second heat exchanger. The last heat exchanger is used to charge and discharge the solar buffer tank. Here the solar thermal energy not required in collector mode is placed in a buffer. Charging is to occur on a temperature-controlled basis. Storage tanks with appropriate direct layered charging equipment are to be used for this purpose. If the solar supply temperature is two Kelvin over the temperature in the lowest tank area, buffer charging then occurs during collector mode. The discharging of the buffer tank takes place during a period in which the collector circuit is not delivering solar thermal heat. As soon as the temperature on the collector field is no longer sufficient for any solar functions, collector mode is switched off and the buffer tank is discharged until the temperature in the top tank area falls below twenty-nine degrees. Collector mode also ends at this temperature on the collector sensor. If solar output cannot be produced to a sufficient extent with the connected collector field, the remaining portion is provided via the second heat exchanger.

Findings

Spec. heating requirements:	Block construction	74.7 kWh/m²a	-46%
	Masonry construction	78.1 kWh/m²a	-48%
Total final energy consumption:	approx. 600 MWh/a	-45%	
Solar gain in 2010:		43,000 kWh/a	
Building construction (cost type 300):		1,130,000.00 €	
Equipment (cost type 400):		463,000,00 €	

By improving the efficiency of the building envelope and optimising the equipment, a decrease in heating requirements by an average of 47% was achieved. Thanks to the intelligent system solution, optimal exploitation of the solar collector panels was achieved, a result also demonstrated through measurements taken in 2010 (see Figure 5).

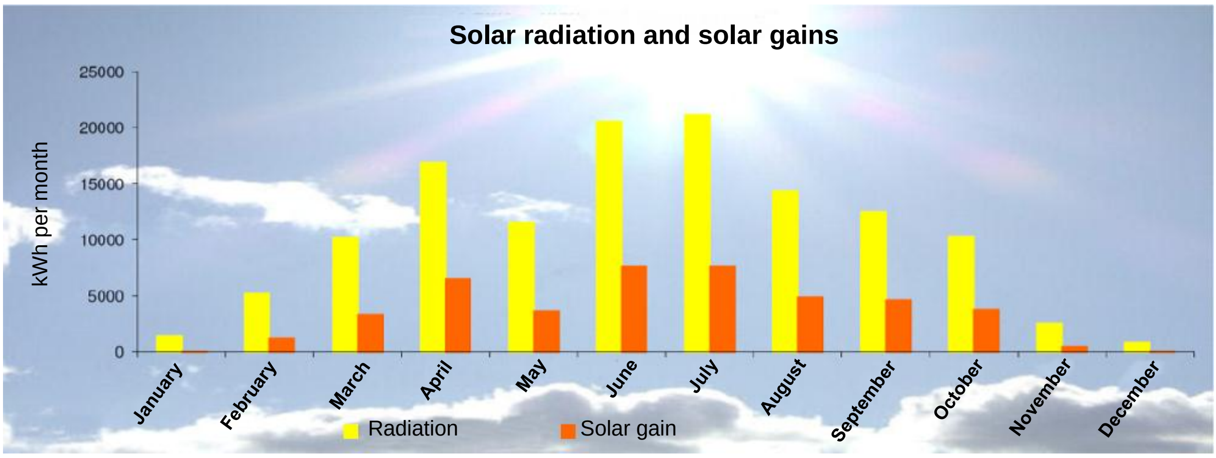


***Figure 5**: Measurement 2010 (Source: Parabel Energiesysteme GmbH)*

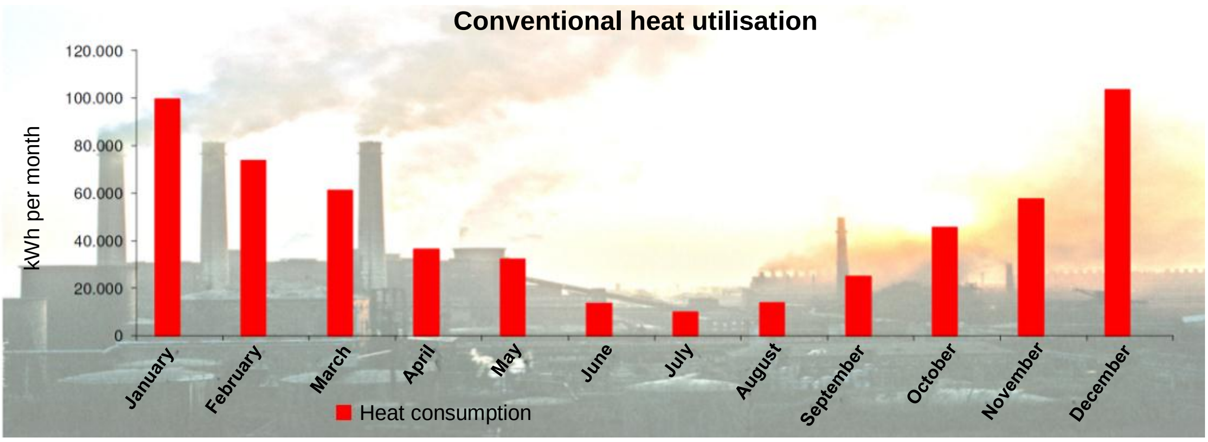


***Figure 6**: Measurement 2010 (Source: Parabel Energiesysteme GmbH)*

WP 4 Energy Supply

Best practice

Energy upgrading of the building stock in combination with district heating from renewable energy sources

***Figure 7**: "Cohnsches Viertel" solar heating system (Source: City of Hennigsdorf)*

***Figure 8**: Biomass power plant (Source: KPG)*

General information

Address :	Cohnsches Viertel, City of Hennigsdorf
Contracting party:	Hennigsdorfer Wohnungsbaugesellschaft mbH / Stadtwerke Hennigsdorf
Building type:	Multiple family dwelling quarter with masonry construction
Primary energy source:	District heating (Stadtwerke Hennigsdorf)
Habitable area:	30,436 m² (Cohnsches Viertel – heating requirement share)
Residential units:	525
Year built:	1950's
Implementation:	2001 -2011
Spec. heating requirements:	approx. 160 kWh/m²a
Total final energy consumption:	approx. 4,870 MWh/a

Measures

With its city-wide energy concept, the city of Hennigsdorf strives toward achieving the goals of high-efficiency heat supply and meeting the climate protection goals set forth in the Energy Savings Act and the Act on the Renewable Energies in the Heat Sector. This goal has already been implemented through a combination of individual components including cross-quarter modernisation strategies and will be further intensified in the future. By way of example, the strategy for the Cohnsches Viertel residential quarter will be gone into in greater depth here.

Components of this modernisation strategy in Cohnsches Viertel in the building stock:

1. Partial insulation of the outer walls (4 cm)
2. Insulation of the top storey ceilings (10 cm)
3. Insulation of the cellar ceilings (5 cm)
4. New windows
5. Replacement of the heat pumps and control optimisation using adapterm

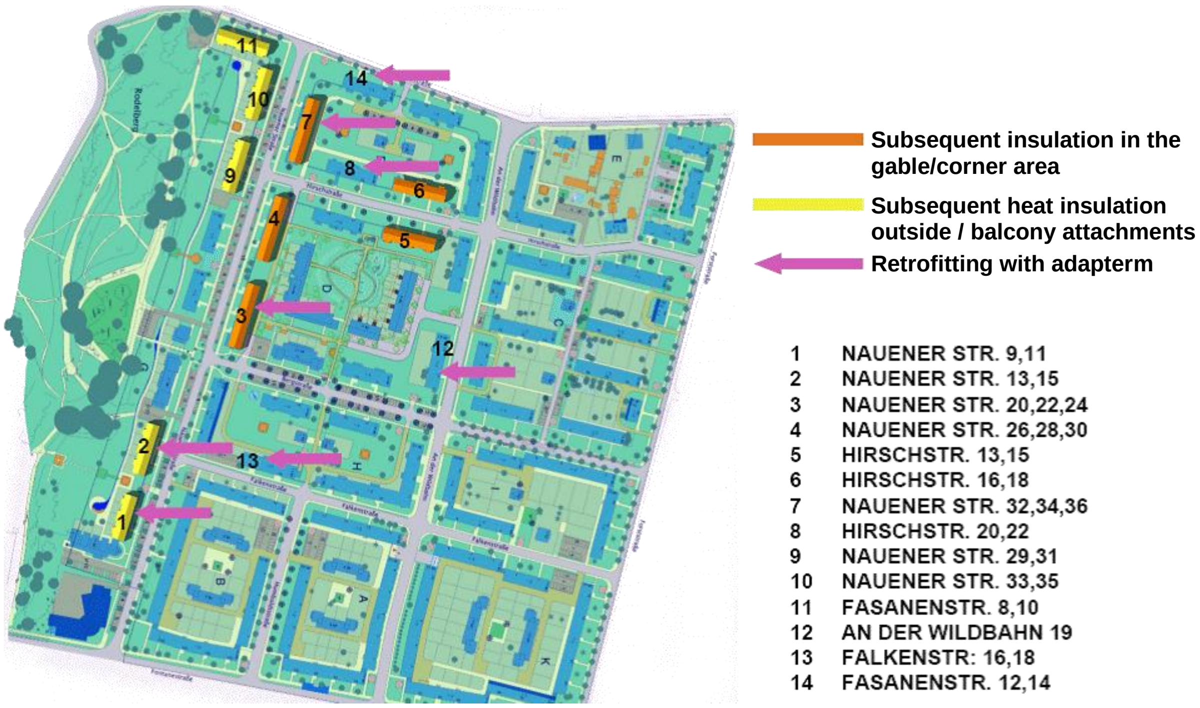


Figure 9: *Excerpt of modernisation measures - heating requirements (Source: HWB 2009)*

Components of the energy mix in Cohnsches Viertel for heating and hot water:

1. Setup of a solar heating system to contribute to help provide for hot water and heating requirements
2. Block heat power plant with 3 modules (district heating)
3. Biomass power plant (district heating)
4. Biomass block heating power plant (district heating)

The energy mix for Cohnsches Viertel is strongly characterised by its multifacetedness which, to a significant extent, has been implemented thanks to the forward-thinking strategy of the Stadtwerke (public utility company). Using the solar heating system, heat is generated directly in Cohnsches Viertel. The remaining heating requirements (90%) are met by the Stadtwerke's district heating grid.

Solar heating system output:	856 m² spread out on 5 roofs
	90% annual use
	10% coverage of total heating requirements
Block heat power plant output:	3 x 1.065 MW in power generated
	3 x 1.5 MW in thermal output
	Annual use > 70%
	Run time 7,000 h/a (full)
Biomass power plant output:	2.2 MW in power generated
	9.8 MW in thermal output
	Annual use 84%
	Run time 6,900 h/a (full)
	Wood requirements, dry 20.000 t(atro)/a
Biogas block heat power plant:	1.200 MW in power generated
	2.945 MW in thermal output
	Annual use 87%
	Run time 5.000 h/a (full)

Detailed description of measures

The 1st component of the overall strategy for Cohnsches Viertel involves energy efficiency improvements to the buildings. Due to listed building group protection, it was however not possible to insulate the entire building envelope. For this reason, the decision was made to insulate the storey ceilings (10 cm), the cellar ceilings (5 cm), replace the windows and implement partial energy efficiency improvement measures of the facades (4 cm). In some buildings, only the gables were insulated and in others the entire facades were insulate (see Figure 9), a fact which resulted in different final energy savings of the individual buildings.

In the second step, the equipment was adapted to the new heating requirements, which made it possible to reduce the connected district heating load. By installing a solar heating system, with an average annual use of 90% in 2006 on 5 roofs in Cohnsches Viertel, heating requirements were once again decreased by 10 %. Later on in the course of energy modernisation, on the secondary side, the district heating in the buildings, the feedback control systems and the pumps were replaced and/or optimised.

Subsequent steps to achieve the anticipated heating requirements over the next several years will focus on low-investment measures involving the introduction of energy management systems. In some buildings (see Figure 9), adapterm systems have already been integrated. adapterm systems work on the basis of information from the radio heat cost allocators and equipping the building with mains-operated data collectors. These receive the information from the radio heat cost allocators and using, a specially designed algorithm, calculate the actual heating requirements in the building from this data. Thanks to this information, the supply can be adapted to the actual requirements and energy use can be lowered. (see Figure 10).

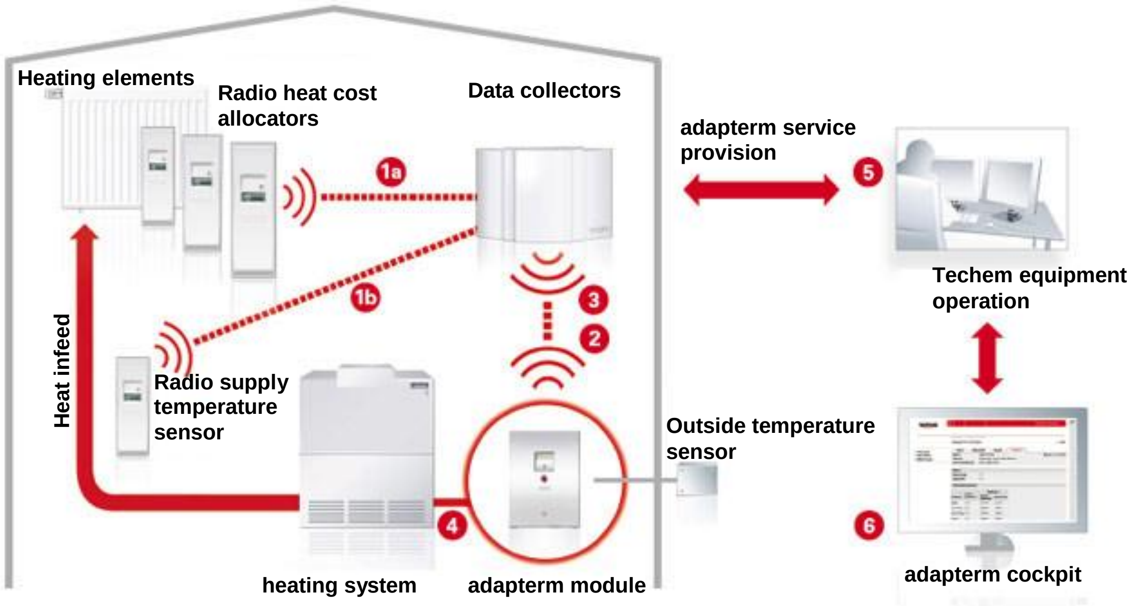


Figure 10: *adapterm conceptual design (Source: Techem)*

The second component is the integration of the Stadtwerke (public utilities). Although the city-wide strategy is the focus here, connecting the Cohnsches Viertel to district heating is also considered one of the most important components.

In order to meet the requirements for optimum district heating with low CO2 emissions, a city-wide strategy was implemented over the last several years. The strategy included the renovation, modernisation and linking of existing structures with regard to district heating. An example for this strategy is the district heating charter of 1997 and its amendment in 2007, the consistent expansion of the district heating grid from 12 km (1993) to 48 km (2011) and the tripling of the heat sales volume from 40,000 MWh (1996) to 125,000 MWh (2003) where, with the connection of Bombardier in 2003, a major consumer of district heating was hooked up to the grid (see Figure 11). One can also see in Figure 11 that the heat consumed by the existing consumers fell by more than 50% as a result of the energy efficiency improvements to the building stock of the city of Hennigsdorf. The percentage of consumers supplied with district heating within the city limits of Hennigsdrof encompasses 80 % of households, 70% of municipal institutions and 70% of commercially used buildings.

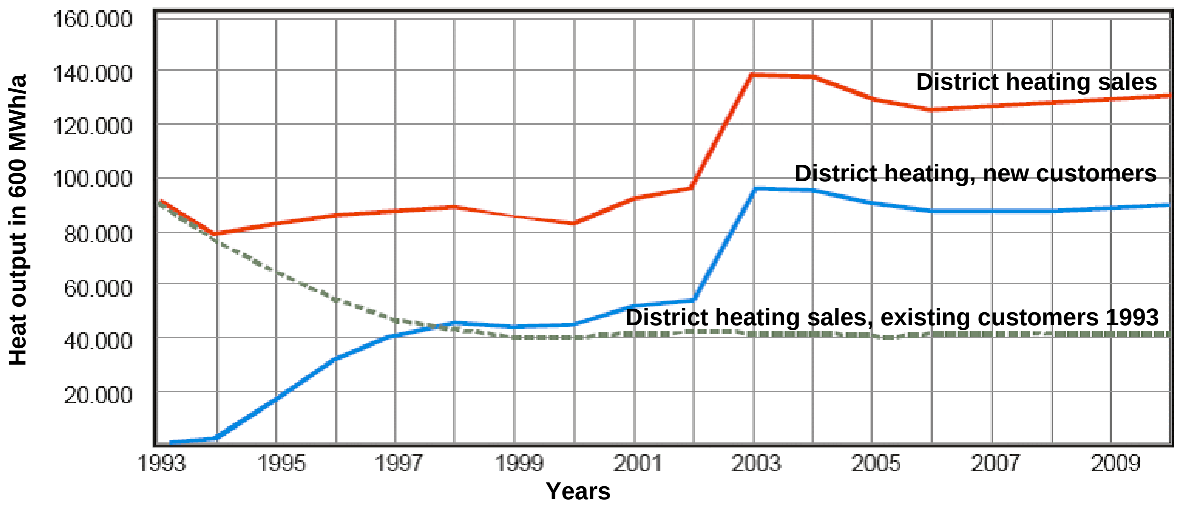


***Figure 11**: Changes in Stadtwerke figures (Source: Stadtwerke Hennigsdorf SWH 2011)*

These measures represent the basis for the modernisation of the existing equipment and the construction of 5 new CHP/thermal power plants. The investment costs of Stadtwerke Hennigsdorf with its subsidiary (KPG GmbH) were 63.45 million Euros since 1992. Since then, just under 60 % of district heat is generated using renewable energies, which, in conjunction with generation using combined heat and power plants (CHP), resulted in a primary energy factor of 0.06, thus fulfilling the target of the EEWärmeG for all citizens and investors hooked in to the district heating grid.

Findings

With its two municipal companies, Stadtwerke Hennigsdorf and Hennigsdorfer Wohnungsbaugesellschaft (Hennigsdorf Apartment Building Company), the City of Hennigsdorf has exemplified that energy efficiency is also possible from the point of view of listed building protection with a combined approach incorporating the building envelope, user and equipment.

Renewable heat generation:	Solar heating system	350 MWh/a
	Block heat power plant	32,000 MWh/a
	Biomass power plant	67,600 MWh/a
	Biomass block heating power plant	6,000 MWh/a
Renewable power generation:	Block heat power plant	21,000 MWh/a
	Biomass power plant	14,500 MWh/a
	Biomass block heating power plant	6,000 MWh/a
Total CO_2 savings:	approx. 40.000 t/a (equipment and district heating)	
Investment Total district heating:	€ 63.45 mil. (1992-2011)	
Renewable district heating percentage:	57%	
CHP district heating percentage:	77%	
Spec. final energy requirements:	129 kWh/m²a -20%	
Total final energy consumption:	approx. 3,870 MWh/a	-22%

Best practice

Energy modernisation and supply of district heating from renewable energy sources to listed structures.

Figure 12: *Grünstraße Solar heating system (Source: Parabel Energiesysteme GmbH)*

General information

Address :	Schwedter Straße 25, 27 and 29 in 17291 Prenzlau
Contracting party:	Wohnbau Prenzlau GmbH
Building type:	Multi family dwelling quarter with masonry construction with wooden beam ceilings and Berlin-style roof.
Primary energy source:	Lignite single ovens prior to modernisation
	District heating (Stadtwerke Prenzlau (Prenzlau public utilities company) after modernisation
Habitable area:	2,888 m^2
Residential units:	25
Year built:	1900 (Schwedter Str. 29) 1918 (Schwedter Str. 25, 27)
Implementation:	2011
Spec. final energy requirements:	195 kWh/m^2a on average
Total final energy consumption:	approx. 563 MWh/a

Measures

The group of buildings in Schwedter Straße is made up of 2 buildings with number 29 listed as a historic building. The redesign contract was awarded as part of an assessment procedure in which the "keller mayer wittig architekten stadtplaner bauforscher" firm managed to win over the decision panel with its perspicuous concept. Despite the decision to forego "classic" insulation on the brick facades, the requirements set out by the EnEV (Energy Conservation Ordinance) of 2009 were met and even exceeded by more than 20%. The goal here was to plan a combined spatial and energy concept.

The following measures were taken to this end:

1. Insulation of the outer wall / interior insulation
2. Insulation of the top storey ceiling / roof
3. Insulation of the cellar ceiling
4. Incorporation of new windows / efficiency improvements to existing box-type windows
5. Connection to the district heat grid with the Stadtwerke Prenzlau
6. Re-installation of all the heating and plumbing facilities
7. Use of decentralised ventilation systems for every flat with waste heat recovery

District heating primary energy factor:	0,0
Provision of district heat:	49.9% from renewable energy and 49.0% from CHP-generated heat
Ventilation:	Decentralised ventiliation systems with up to 92% waste heat recovery and max. air renewal of 180 - 220 m³/h
Façade insulation:	Exterior insulation and finishing system (EIFS) and some interior insulation

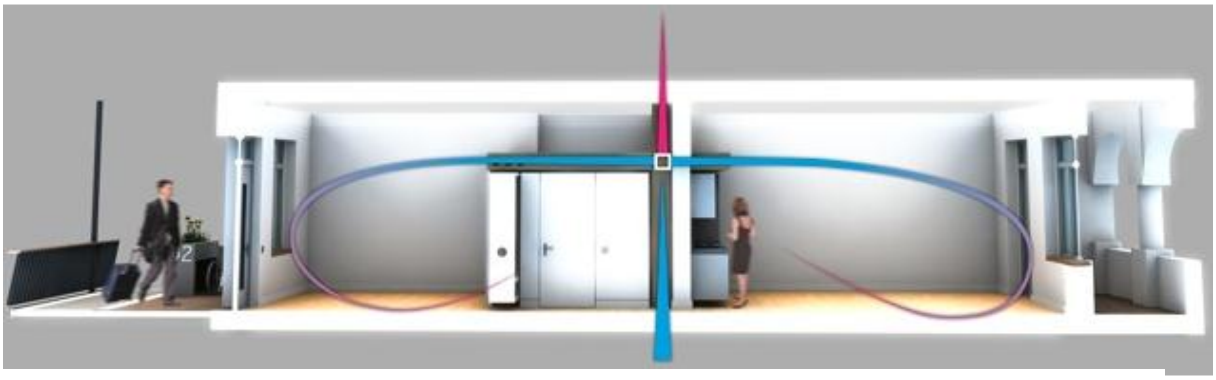


Figure 13: Decentralised ventilation equipment conceptual design (Source: kmw-architekten)

Standardised component structures after modernisation

The vast majority of the components are left in the building stock. The components which are modified or fitted with heat insulation are subject to EnEV 2009 § 9, Appendix 3. The raw density of the existing brick material was estimated at 1800 kg/m³ .
The following insulation thicknesses are planned for the components which are to be insulated: Outer walls 16 cm, WLG 035; storey ceiling 16 cm WLG 035; and floor against the cellar 10 cm WLG 040 from below.

Component	$U_{exist.}$ W/(m²K)	Umax in W/(m²K) pursuant to 2009 Appendix 3	fulfilled yes/no
OW 1 outer wall with EIFS	0.19	0.24	yes
OW 2 outer wall with EIFS	0.19	0.24	yes
OW 3 outer wall in existing stock	1.04	–	pre-existing
OW 3.1 outer wall in existing stock	1.20	0.24	pre-existing
DW 4 Divider wall interior insulation	0.43	0.30	inside wall
OW 5 outer wall with EIFS	0.19	0.24	yes
OW 6 outer wall in existing stock	1.47	–	pre-existing
OW 7 outer wall in existing stock	1.15	–	pre-existing
OW 8 outer wall in existing stock	1.23	–	pre-existing
DW 9 outer wall in existing stock	1.67	–	pre-existing
OW 10 outer wall in existing stock	1.47	–	pre-existing
D 1 Ceiling to non-upgraded roof	0.17	0.24	yes
CD 1 Ceiling roof	0.22	0.30	yes
FF 1 Window replacement	1.30	1.30	yes
FF 2 Box window upgrade	1.10	1.30	yes

***Table 3**: Standardised component overview for the planned modernisation (source: Dr. Monika Weineck, engineer)*

Figure 14: Ground floor plan

Figure 15: First storey floor plan

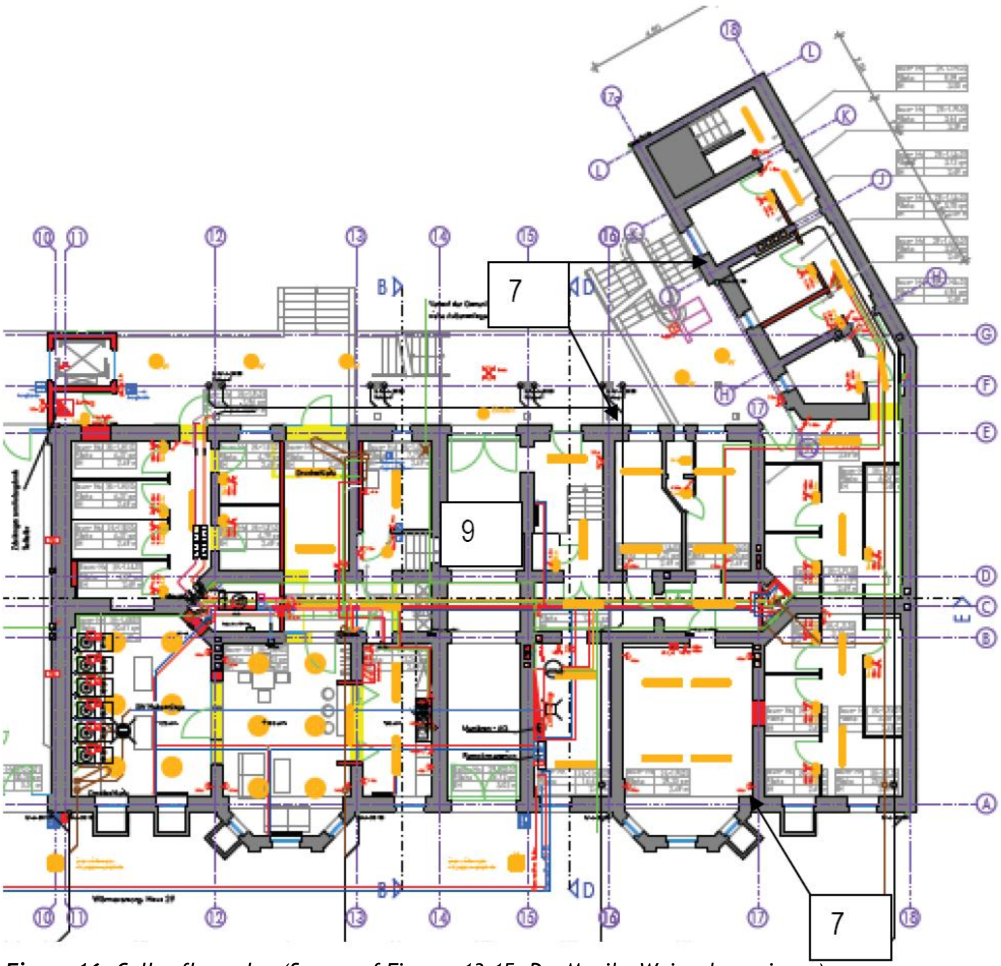


Figure 16: *Cellar floor plan (Source of Figures 13-15: Dr. Monika Weineck, engineer)*

Detailed description of measures

The apartments comprising the partially listed group of apartments in Schwedter Straße 25-29 are quite deep (14 m) and very high ceilings in some cases over 3.5 m. Due to the great depths and heights of the apartments, the building stock has a very favourable ratio of volume to external area (EA/V ratio). This situation was used with a view to energy efficiency in order to concentrate the work on intelligent ventilation rather than on "classic insulation" so as to reduce heating requirements.

The planning concept developed by the architecture firm provided for a bath "box" with a decentralised ventilation system and waste heat recovery of at least 95% (Fig. 2). A cast ventilation system ensures hygienic air conditions and prevents mould from forming. A mechanical exchange of air between 180 und 240 m^3/h is required for each flat, which enables optimum heat recovery which in turn results in a low air current through the heat exchanger and thus effective heat transfer (Figure 17).

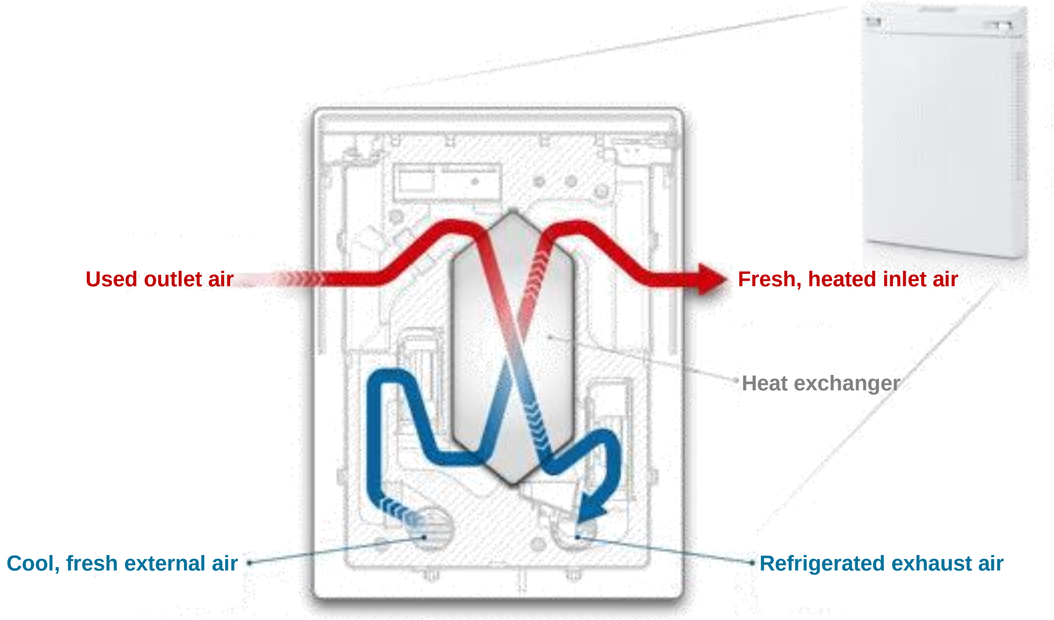


Figure 17: *Waste heat recovery using heat exchangers conceptual design (Source: Helios)*

It was only possible to insulate the outer walls to a partial extent due to historic building protection issues. In areas where insulation could be installed, up to 16 cm of insulating material was planned. In areas of the interior walls and passages, partial interior insulation was planned. In the area of the street-facing facade, the old box windows will be upgraded and the inside leaves replaced with heat insulating glass, thus making it possible to go below the EnEV for these existing windows (Table 3). The risk of condensation occurring in the non-insulated facade areas will be prevented by maintaining the minimum thermal insulation and factoring in the decentralised ventilation systems.

The storey ceilings to the non-heated attic and cellar ceilings will be insulated pursuant to EnEV, even falling below it in places.

As a result of the non-insulated components and falling below the structural components to be equipped with insulation, the requirements in terms of transmission heat losses will be met and even gone below.
The third major point in the energy modernisation concept provides for integration in the district heating system of Stadtwerke Prenzlau. Stadtwerke Prenzlau generates, at the rate of 49.9%, heat it supplies using renewable energy (geothermal and wood). In addition 49% of the heat supplied is produced in CHP (Figure 18). In the building stock, heating requirements are satisfied by tiled ovens and hot water requirements are provided for using electric energy in the form of boilers and continuous flow heaters. Due to the Stadtwerke's primary energy factor of 0.0, meeting primary energy requirements poses no problem (Figure 25).

Zertifikat

Hiermit wird bescheinigt,
dass auf Grundlage der im Zertifizierungsbericht[1] genannten Betriebsdaten des Jahres 2009

das Fernwärmeversorgungssystem Innenstadt/Am Durchbruch der Stadtwerke Prenzlau GmbH

Primärenergiefaktor des Fernwärmeversorgungssystems:	0,00
Die Wärmebereitstellung erfolgte mit einem Anteil von aus regenerativ erzeugter Wärme.	49,9 %
Die Wärmebereitstellung erfolgte mit einem Anteil von aus in Kraft-Wärme-Kopplung erzeugter Wärme.	49,0 %

Certificate

This certifies,
on the basis of the 2009 operating data mentioned in the certification report[1],

the District Heating Distribution System of Stadtwerke Prenzlau GmbH, located in the City Centre/Am Durchbruch

Primary energy factor of the district heating supply system:	0,00
Percentage of heat supplied generated using renewable energy sources.	49.9 %
Percentage of heat supplied generated in combined heat and power plants.	49.0 %

***Figure 18**: Excerpt Stadtwerke Prenzlau district heating certificate (Source: Stadtwerke Prenzlau (Prenzlau public utilities))*

The distribution of thermal heat and hot water is carried out via centrally arranged pipes enabling hydraulic adaptation and flat wise billing using heat quantity meters. The thermal heat is transferred using convectors. Due to the wooden flooring and the potential for high supply temperatures due to district heating, floor heating is not to be used.

The following funds were made available for the modernisation of the buildings:
- State loan under apartment construction funding programme item 5.6.1.
- KfW senior housing convention loan (155)
- Subsidy pursuant to the elevator directive
- Construction cost subsidy pursuant to the urban construction funding directive

Findings

Spec. final energy requirements:	79 kWh/m²a	-59%
Total final energy consumption:	approx. 228 MWh/a	-59%
Cost estimate, building construction (cost type 300):	1.600.000,00 €	
Cost estimate, equipment (cost type 400):	400.000,00 €	

The combination of an intelligent ventilation system with waste heat recovery, partial energy efficiency improvements to the building envelope and the use of district heating with a large percentage of heat generated using renewable energy sources and CHP makes it possible to go below the required levels as per EnEV 2009 vis-à-vis a modernised old construction by more than 50 % and by 10% compared with a new building.

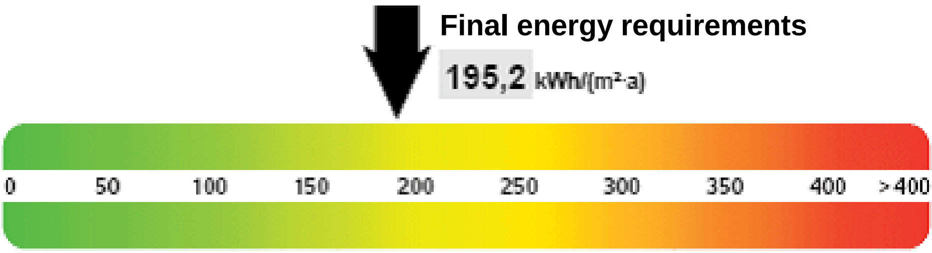


***Figure 19**: Final energy requirements prior to modernisation (source: Dr. Monika Weineck, engineer)*

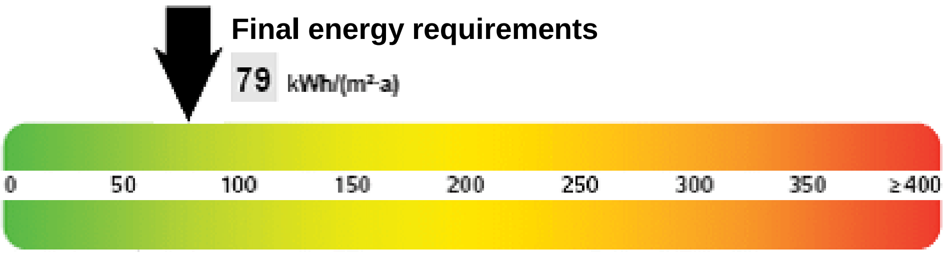


***Figure 20**: Final energy requirements after modernisation (source: Dr. Monika Weineck, engineer)*

WP 4 Energy Supply

Best practice

Low-investment measures for optimisation of costs and consumption in secondary side district heating

Figure 21: *Arial view (source: BBP Bauconsulting GmbH)*

General information

Address:	Wenigerode new construction residential area
Contracting party:	Gebäude- und Wohnungsbaugesellschaft Wernigerode mbH -GWW-
Building type:	Multiple family dwelling quarter with block construction Residential building series 70 (German WBS70) and P2
Primary energy source:	District heating
Habitable area:	61,708 m^2
Residential units:	29 housing blocks with a total of 1,124 RU
Year built:	1980-1985
Implementation:	2009/2010
Spec. heating requirements:	170 kWh/m^2a
Total final energy consumption:	approx. 9,309 MWh/a

Measures

The entire building complex in Wernigerode with a total of 29 buildings will be completely supplied with district heating. The goal of the measures in Wernigerode was to optimally adapt the existing heat distribution grids on the secondary side to the actual requirements, thus reducing energy costs and unnecessary consumption in the buildings over the long-term. Another objective was to check to what extent step-by-step implementation is possible and what savings can be generated in such a way.

The engineering firm "BBP Bauconsulting mbH" was charged with planning and implementing the following steps.

1. **Step:**
   Consumption analysis and derivation of optimisation measures
2. **Step:**
   Calculation of new connected loads and optimisation of the control system
3. **Step:**
   Optimisation of the hydraulics (in implementation)

Figure 22/23*: (Source: BBP Bauconsulting mbH engineering firm)*

Detailed description of measures

Step1: Consumption analysis and derivation of optimisation measures

In the first step, the inspection, data recording at the heating stations and determination of the control parameter settings were carried out. At the same time, a stocktaking of the heat distribution network, including an inspection of the balancing and heating element valve settings was completed. Based on this, the energy consumption for each heating station from the heating energy bills for the last 3 years were analysed. In order to enable a comparison of different sized buildings, the consumption data were adjusted for weather and related to the heated area. These values were compared with the current heating survey. Higher than average consumption levels became evident thanks to this method. Using the analysed data, it was possible to make initial adjustments to the control parameters of the building connection stations. The (then) current connected loads were evaluated and adjusted in an initial phase and the expected savings were predicated.

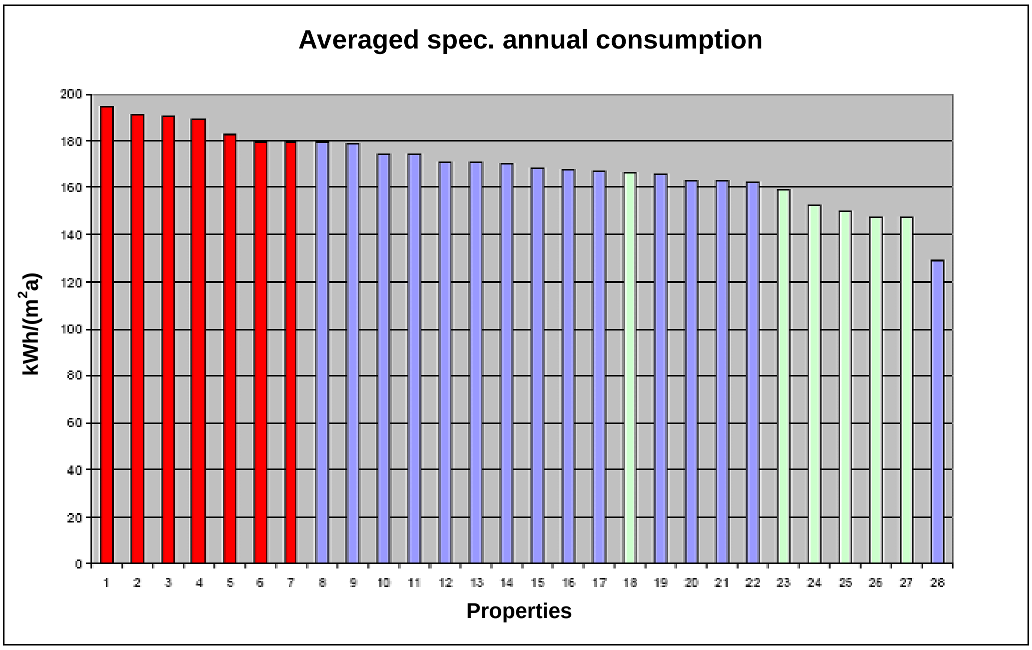


***Figure 24**: Averaged spec. annual consumption (Source: BBP Bauconsulting mbH engineering firm)*

The costs of the engineering assessment for the first step amounted to a gross figure of around 0.20 €/m².

Step 2: Calculation of new connected load and optimisation of the control system

Further data recording (continuous recording of consumption values in a 14 day interval), it was possible, in an initial step to concretise and evaluate the determined connected loads. The required thermal loads for heating (independent of weather conditions) and water heating (nearly constant) were determined for this calculation. At the same time, the control settings (e.g. increase in the heating characteristic curve, base point, bend, heating temperature limit) were adjusted to the requirements of each building type.

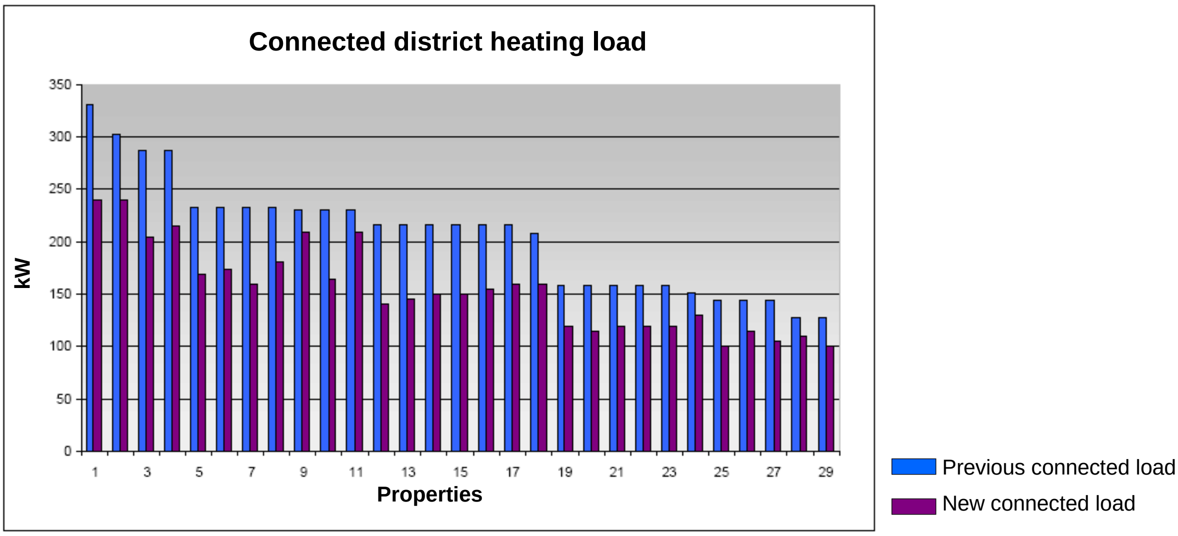


***Figure 25**: District heating connected load before/after (Source: BBP Bauconsulting mbH engineering firm)*

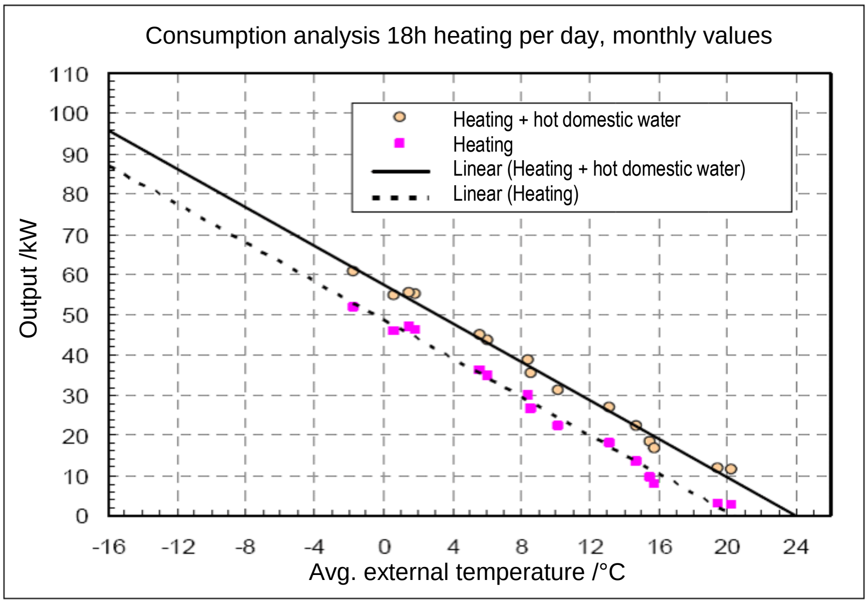


***Figure 26**: Consumption analysis (Source: BBP Bauconsulting mbH engineering firm)*

The costs of all the measures (steps 1 and 2) amounted to a gross figure of 0.49 €/m².

Step 3:

Other savings opportunities can be achieved by optimising the hydraulics. In the areas under consideration, heat is distributed in the buildings via single-pipe heating. It is necessary to limit the return flow temperatures for optimal operation. This possible using a line regulating value with a thermal attachment. The pipe return flow temperature to be limited can be configured on this attachment. If this temperature is exceeded, then the volume flow can be reduced via the regulating valve. In single-pipe systems especially, this return flow regulation holds a great deal of potential for savings. Since the valve is set for the volume flow of each pipe, it is absolutely necessary to record the existing pipe data (incl. heating element data) and re-compute them. The necessary measures are currently being compiled.

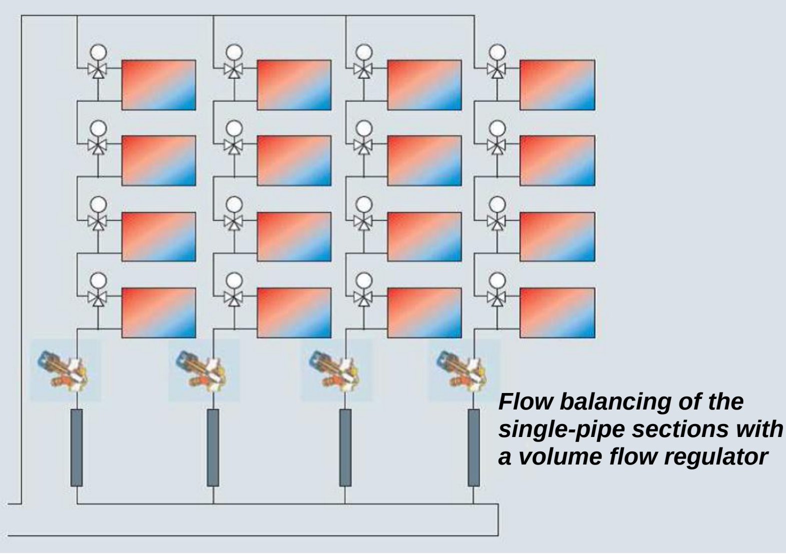


Figure 27: *Illustration of flow balancing (Source: BBP Bauconsulting mbH engineering firm)*

Figure 28: *Line regulating valve*

The required investment costs were estimated at approx. 5.34€ (gross)/m² (4.1 € (gross)/m² for structural and 1.24 €(gross)/m² for engineering services).

Findings

Connected district heating load:	4,485 KW	-25%
Final energy consumption:	7,620 MWh/a	-18%
Investment costs for steps 1 and 2:	0.49 € gross/m²	
Steps 1 and 2 savings	2.08 € gross/m² + year	
Prog. Investment costs for step 3:	5.34 € gross/m²	
	(4.1 € gross/m² structural costs	
	1.24 € gross/m² + eng/tech. services)	
Prog. savings for step 3:	0.99 € gross/m² + year	

By implementing steps 1 and 2 it was possible to reduce consumption, adjusted for weather conditions, by up to 18%.

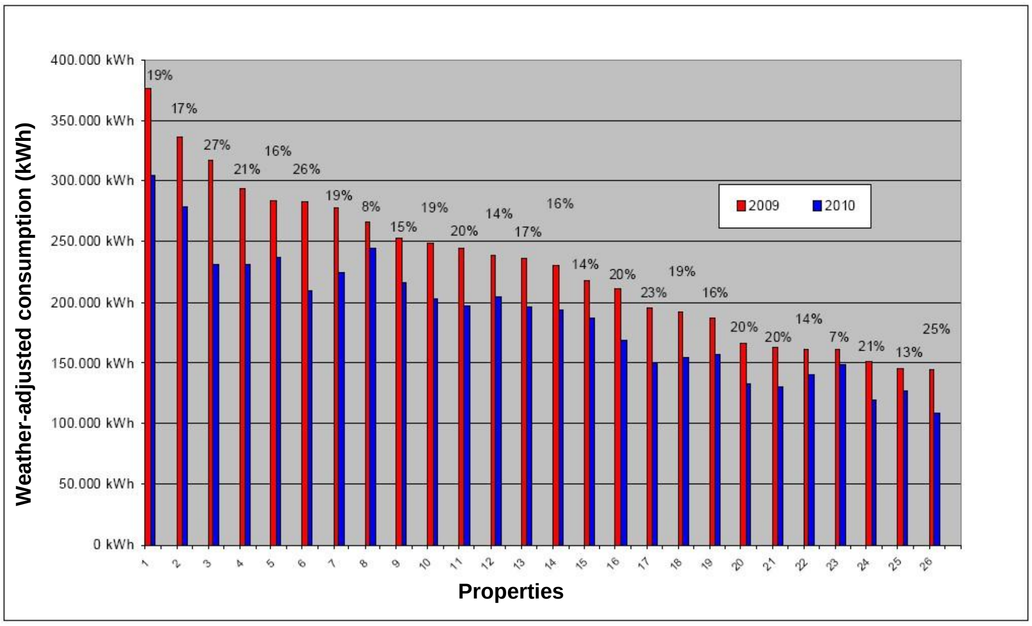


***Figure 29:** Savings through optimisation of control settings*
(Source: BBP Bauconsulting mbH engineering firm)

Thanks to the process in steps 1 and 2, the contractually stipulated total connected load of 5,973 kW was successfully reduced to 4.485 kW. This corresponds to a decrease of approx. 25%.

Conclusion

The examples presented clearly show how energy concepts have been implemented at the quarter level in Brandenburg. The crucial component to linking the heat supply of different buildings is a common heat generation and distribution system. This combines, in general, centralised and decentralised energy generation systems in a heating grid. The major advantage with a larger number of consumers is, on the one hand, decreasing relative investments and, on the other, increased energy efficiency thanks to better capacity utilisation of the systems (increasing number of full-load hours and improved efficiency). Consequently, this results in a lower financial burden on stakeholders and a decrease of primary energy consumption. The example of the City of Wernigerode demonstrates that complete replacement of the heating system and comprehensive insulation measures are not necessary. Generally speaking, an energy consultation by experts can shed light on many opportunities for improving efficiency by upgrading or integrating existing system components. By way of example, the projects often point to the use of an existing district heating system which offers feed-in points for various energy producers, yet can be centrally controlled. The development of such a grid usually calls for a larger central generation unit which covers the basic load. Volatile producers (e.g. solar thermal energy) can, as needed, be called up through the interposition of buffer tanks.

In general, it was determined that a district heating grid in urban quarters is an optimum technical solution. This grid offers the point of departure for a number of other measures which can be taken to optimise efficiency: energy efficiency improvements to the building envelope, decentralised, renewable energy sources, forced ventilation and/or waste heat recovery and flow balancing.

Credits

Energy efficiency and renewable energies in residential areas
Best practice examples from Brandenburg Land

Published by:

Industrie- und Handelskammer Potsdam
Location Policy / Innovation / Environment / Projects
Brandenburg Energy Technology Initiative ETI
Breite Straße 2 a-c
14467 Potsdam

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IHK Potsdam thanks all those involved in the project for their collaboration.