



THERMOS

Baseline Replication Assessment Report – Pilot Cities

20.03.2018



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Contents

1 Introduction..... 4

2 Berlin..... 5

2.1 Introduction..... 5

2.2 Heating and Cooling in the Local Context 6

2.3 Stakeholder Identification and Engagement 16

2.4 Towards THERMOS Uptake 25

2.5 THERMOS Case Study 26



1 Introduction

The Baseline Replication Assessment Report aims to map-out and assess the national and local framework conditions for a successful adoption of the THERMOS model.

This document constitutes the final issue of the Baseline Replication Assessment Report and focuses on the four Pilot Cities of the THERMOS project: Granollers, Islington, Jelgava and Warsaw, and the 4 Replication Cities: Alba Iulia, Berlin, Cascais and the Greater London Authority.

Throughout this document the most relevant characteristics and features that should be considered for the adoption of the THERMOS tool are analysed. The analysis covers the following elements in each of the four Pilot Cities studied:

- **Heating and Cooling in the local context:** this section contains an analysis of the local energy system (energy mix, key performance indicators on power and thermal supply and demand), the key energy policy and legislation, the adoption of Renewable Energy Sources (RES) in the city and the existing energy objectives and plans, among others;
- **Stakeholder Identification and Engagement:** the main local and national stakeholders that should be engaged for a successful adoption of the tools developed throughout THERMOS are listed in this section, together with the roles that they can hold towards the THERMOS model replication and the strategies to be followed for their engagement;
- **Towards THERMOS Uptake:** in this section the principal barriers that could prevent the adoption of the THERMOS tool and the solutions to overcome them are examined;
- **THERMOS Case Study:** finally, the document focuses the analysis on a single opportunity in a city district or quarter where the THERMOS tool will initially be applied.

This report is therefore meant to establish a baseline and serve both as a guide and a set of practical examples on the information that should be gathered and the stakeholders that should be engaged for a successful replication and adoption of the THERMOS tool.



2 Berlin

2.1 Introduction

Berlin is the capital of Germany with a population of about 3.4 million people. It is located in the north-east of Germany and with 892 km² is the largest city in the country. The climate in Berlin is warm and sometimes humid in summers with average temperatures around 25°C and cool winters with average temperatures around 0°C. Berlin's built-up area covers about 42% and forests and trees make up another 18%. This leads to microclimates where temperatures in the city centre can be up to 4°C higher than in the suburbs.



Source: ©Shutterstock/AR Pictures

From 1948 until 1990 the city was divided into East and West Berlin. Germany consists of 16 states and with the reunification on 9 November 1990 Berlin became one of three city states in the country.

The political system in Berlin consists of the House of Representatives (Abgeordnetenhaus), and the executive body, which is the Senate of Berlin (Berliner Senat, or Landesregierung). Berlin is divided into 12 boroughs (Bezirke) where each borough is made up of several sub districts or neighbourhoods. These boroughs have their historic roots in much older municipalities and were urbanised and incorporated into the city only with the formation of Greater Berlin in 1920. Each of the 12 boroughs is in charge of their administrative tasks and has their local mayor. Furthermore these 12 boroughs are divided into 96 sub districts, which are made up of several smaller residential areas or quarters.



Source: Senatsverwaltung für Stadtentwicklung und Wohnen (2017)

Berlin's economy has seen a substantial increase in both in terms of economic growth and rise in employment. The service sector is the dominating sector with around 84% of all companies doing business in services. Important economic sectors in Berlin include public service, education and health services, industry, commerce, transport and logistics, hospitality, consulting services, property development, communication and media, finance and insurance, and arts and entertainment.

Berlin is furthermore one of the main start-up and innovation hubs in Europe. The start-up scene is booming and in 2015 start-ups in Berlin raised more venture capital than start-ups in London. Out of the top 30 rated start-ups in Germany 20 have their headquarters in Berlin.

2.2 Heating and Cooling in the Local Context

2.2.1 Local energy system

2.2.1.1 Introduction

The energy sector consists of three main subsectors: electricity, heat and gas. Berlin's two largest energy providers for private households are the Swedish Company Vattenfall and the Berlin-based company GASAG. Both offer electric power and natural gas supply. Vattenfall is operating and holding the largest part of the existing district heating networks in Berlin – the central and some local networks. A much smaller share of heating networks is operated by smaller companies such as Fernheizwerk Neukölln AG, BTB GmbH, Harpen EKT GmbH and EAB



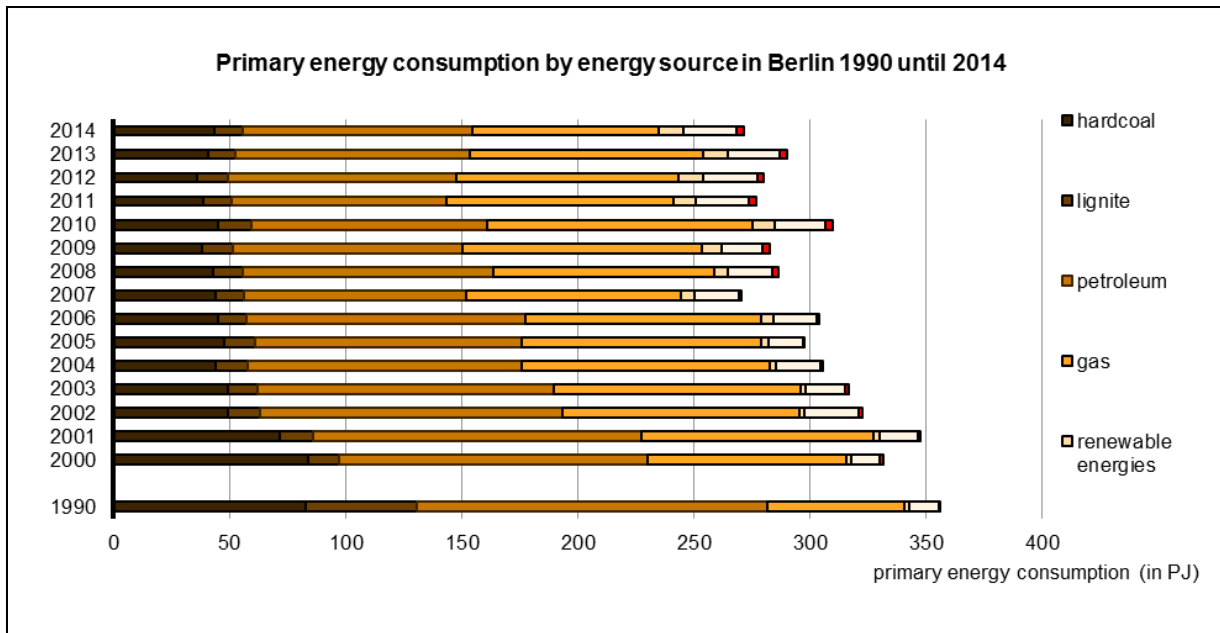
Fernwärme GmbH. Berlin's district heating network is about 1,800 km long and supplies about 1.2 million households with heat. Due to the division of Berlin until 1990 there has been a different development in local heat supply. Up until today district heating is much more prominent in East than in West Berlin.

Some of the city's electricity is imported from nearby power plants in southern Brandenburg. Larger power plants with capacities up to 750 MW in Berlin are mainly fuelled by fossil resources. In 2015 a biomass cogeneration plant started operating in *Reinickendorf* with an output of 18 MW_{th} and 5 MW_{el}. It is the first Vattenfall combined heat and power plant in Berlin to use 100% natural wood chips. Around 70,000 tons of sustainably produced biomass - primarily from the region - enable CO₂ savings of up to 26,000 tons per year. The plant supplies around 30,000 households, which belong to the properties of GESOBAU, one of the largest housing companies in Berlin. All of the large power stations in Berlin generate electricity and heat (to supply district networks) at the same time.

The waste-treatment-plant *Ruhleben* of *Berliner Stadtreinigungsbetriebe* (BSR) is amongst the most modern ones in Europe and forms the core of Berlin's waste management. About half of Berlin's annual household waste (about 500,000 tons) is being treated in this plant. Five incineration lines supply the neighbouring *Reuter* power plant with high pressure steam where it is converted into electricity and heat. The heat is then fed into the district heating network. Operator Vattenfall plans to stop hard coal burning at the *Reuter* power plant by 2020. For hot water production, a new power-to-heat plant is to be realised at this site. The construction of this plant, which will have a capacity of 120 MW_{th} and will produce district heating for 30,000 households, started in early November 2017. In addition, the construction of a modern combined heat and power plant in *Marzahn-Hellersdorf* is ongoing. When completed by 2020, the new combined cycle power plant will have a capacity of around 230 MW_{th} for district heating supply and around 260 MW for electricity generation.

Development of primary energy consumption

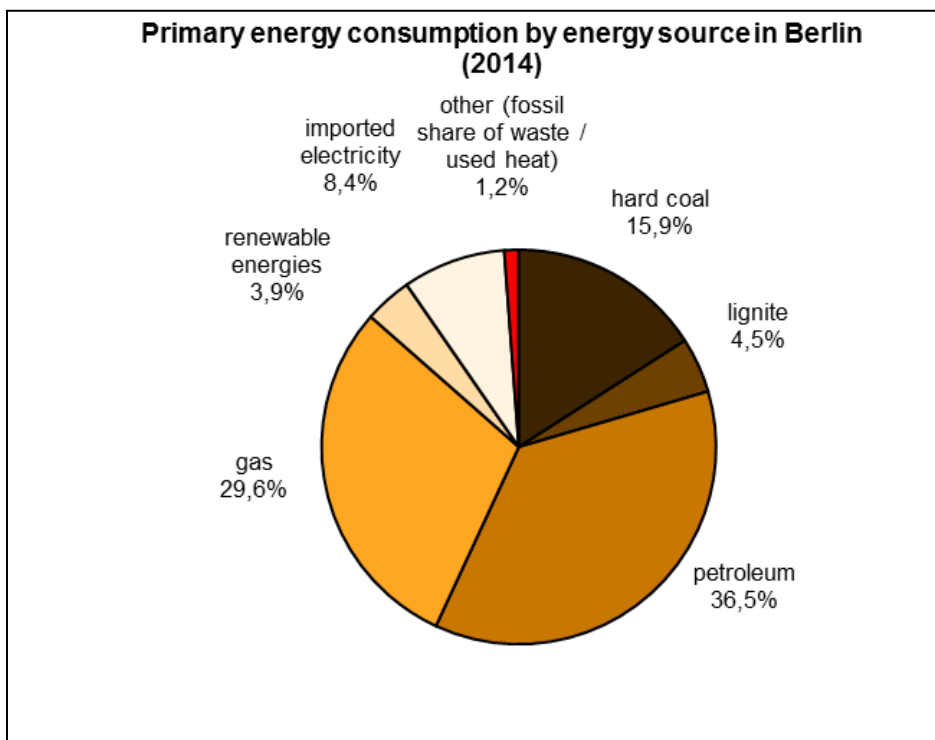
The primary energy consumption of the state of Berlin in the year 2014 was 271.5 petajoule (PJ). This represents a decrease of 23.8% compared with the base year of 1990. In 2014 Berlin accounted for 2.1% of Germany's total consumption.



Source: Amt für Statistik Berlin, Brandenburg, 2017

Primary energy consumption in Berlin in 2014

Hard coal consumption (43.2 PJ) has significantly decreased by 47.8% compared to the base year 1990. Likewise, the consumption of lignite has declined by 74.4% compared to 1990. In 2014 both hard coal and lignite accounted for 20.4% in Berlin’s energy consumption. Natural gas and mineral oils represented, with 66%, the largest group in primary energy consumption in the state of Berlin in 2014.



Source: Amt für Statistik Berlin, Brandenburg, 2017

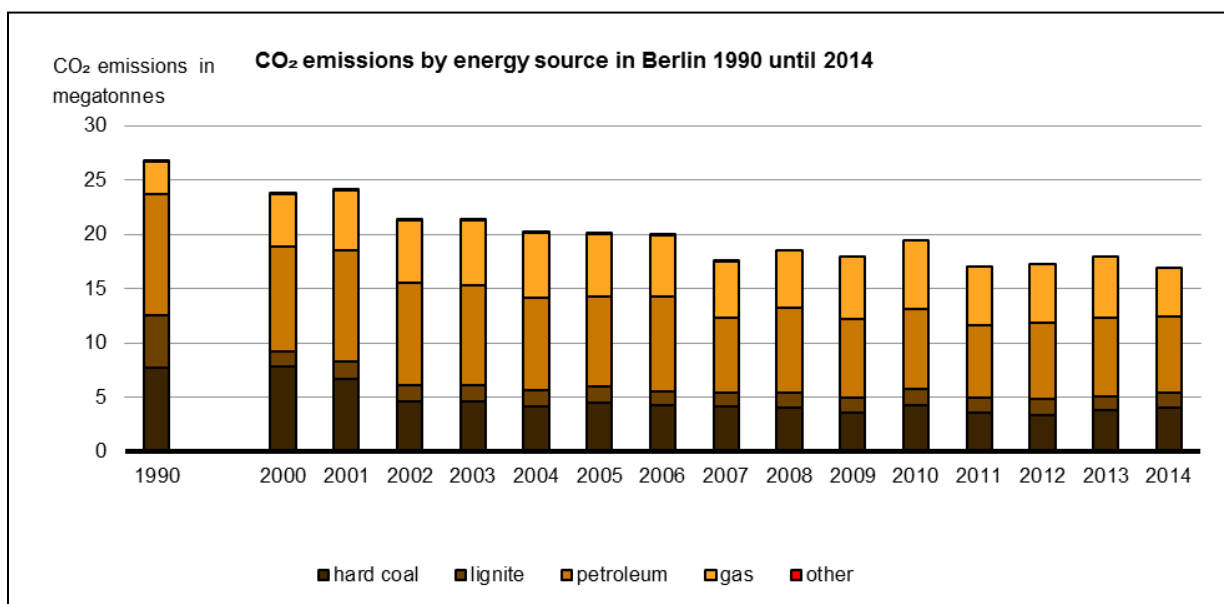


The share of renewable energies in primary energy consumption increased to 3.9% or 10.6 PJ in absolute terms. The share of electricity that was not produced in the state of Berlin and had to be imported rose to 22.9 PJ in 2014. The "other" category includes fossil parts of waste and used heat.

CO₂ emissions based on primary energy consumption

The CO₂ emissions based on primary energy consumption totalled 17 million tons in the state of Berlin in 2014. Overall the output fell by 36.6% compared to 1990.

The emissions from consumption of mineral oils or petroleum, hard coal and burned lignite fell by 36%, 47.7% and 72.6%, respectively, as compared to 1990. Emissions from natural gas consumption increased by 48.6% (to 4.5 million tons) compared to 1990.



Source: [Amt für Statistik Berlin, Brandenburg, 2017](#)

2.2.1.2 Thermal energy supply and demand

Energy supply

Berlin's energy supply is currently characterised by a high proportion (more than 90%) of fossil fuels, including a few older large-scale power plants. While Berlin is considered as the CHP capital, a large proportion of electricity is still generated uncoupled.

Berlin's electricity generation and district heating production and supply are covered by large combined heat and power plants, which are partly hard coal-fired. The share of cogeneration in the district heating supply in 2014 was 81.2% (29,593 terajoule).

Share of cogeneration in Berlin's electricity generation and district heating supply

Indicator	Unit	2005	2010	2011	2012	2013	2014
Total gross electricity generation	TWh	9,109	9,108	8,407	8,121	8,215	7,817



from cogeneration	TWh	4,856	5,797	5,228	5,067	5,001	4,463
share of cogeneration	%	53.3	63.7	62.2	62.4	60.9	57.1
Total gross district heating supply	TJ	41 919	47 355	39 847	40 355	42 174	36 449
from cogeneration	TJ	33 870	37 081	32 103	31 944	31 930	29 593
share of cogeneration	%	80.8	78.3	80.6	79.2	75.7	81.2

Source: Amt für Statistik Berlin, Brandenburg, 2017

Berlin has got a huge potential in basing its CHP production on natural gas. In the decentralised heat sector, oil is also playing a significant role. This shows that there is a significant CO₂ saving potential in the shift from about 70,000 oil heating systems to gas or alternative sources - despite very favourable oil prices.

In general Berlin's share of renewable energies is still low, with the proportion of primary energy and final energy used at around 4% and 2%, respectively. As a result, central and decentralised emission factors are currently rather high both in Berlin's electricity and heat generation. The main challenges for Berlin's energy transition is to exit coal and oil in the medium term, to convert energy more efficiently and to continuously increase the share of renewable energies. In order to achieve this, the existing infrastructure needs to be adapted as well (e.g. reduced temperature levels of heating networks, integrated heat storage) and flexibility options (such as Power to Heat, Power to Gas and Demand Side Management) need to be developed or expanded.

District heating balance of Berlin

Indicator	Unit	2005	2010	2011	2012	2013	2014
Gross district heating supply	TJ	41 919	47 355	39 847	40 355	42 174	36 449
Self-consumption and losses	TJ	1 007	1 039	889	665	3 738	3 763
Statistical differences	TJ	0	202	221	1 290	997	1 415
Final heat consumption	TJ	40 912	46 518	39 179	40 980	39 417	34 024
manufacturing / processing trade	TJ	1 433	1 165	1 451	987	1 097	1 000
households	TJ	37 550	43 742	36 912	39 333	37 396	32 133
Trade, commerce, services and further consumer	TJ	1 929	1 611	816	660	925	891
Fuel provided for district heating in total	TJ	41 318	43 766	36 696	38 865	40 477	34 160
Hard coal	TJ	11 976	11 572	8 838	8 207	9 572	9 065
Lignite	TJ	7 843	7 794	6 681	7 185	6 755	7 180
Mineral oil / petroleum	TJ	880	764	381	660	439	251
Natural gas	TJ	19 341	20 457	17 120	19 215	18 994	13 849
Renewable energies	TJ	767	1 217	1 297	1 553	1 933	1 825
Other	TJ	511	1 962	2 379	2 045	2 784	1 991

Source: Amt für Statistik Berlin, Brandenburg, 2017

Energy demand



The district heating balance of Berlin shows that only a minor share of the total supplied district heat is consumed by manufacturing, trade, commerce and services. In 2014 households consumed 94% of the total final district heat supply.

The building sector accounts for almost 50% of the total CO₂ emissions in Berlin, according to the Berlin CO₂ balance based on the polluter-pays principle. CO₂ emissions in this sector amount to 10.3 million tons and are distributed between residential (~60%), non-residential (~34%) and industrial (~6%) segments. Nearly 200 million m² (gross floor area) are attributable to residential buildings, 66 million m² to non-residential buildings and only 12 million m² to industrial buildings.

In the housing sector, when it comes to refurbishment, the high proportion (about one third) of Wilhelminian style buildings can be a challenge. Their architectural and cultural value needs to be preserved and there tends to be a small-scale ownership structures (flats in the same building are owned by different people), which adds to the complexity of refurbishment and retrofitting projects. Also, the amount of buildings that have been put under preservation order (17.5% of the housing stock based on gross floor area) play an important role when it comes to refurbishment. Average energy consumption in these buildings in 2012 was about 200 kWh per m² net floor area and year. This high heat demand is due to low refurbishment rates and low building standards as well as inefficient heat supply. Here, the heat supply itself must be made more efficient and less CO₂-intense (fuel switch). Additionally, heat losses have to be drastically reduced in Berlin's buildings.

Key performance indicator	
Number and type of energy generation units	Appl. 750,000 heating energy generation units in residential and non-residential buildings
Solar thermal energy generation (MWh/year)	40-45,000 MWh/year (very rough estimate)
Heat pump energy generation (MWh/year)	110,000 MWh/year (very rough estimate)
Biomass energy generation (MWh/year)	Figures not available yet
Waste-to-energy generation (MWh/year)	appl. 640,000 MWh/a district heat (<i>Ruhleben</i>)
Waste heat potential (MWh/year)	Figures not available
Buildings' energy consumption in the residential sector (MWh/year)	8.9 million MWh/year (heat only)
Buildings' energy consumption in the commercial sector (MWh/year)	250,000 MWh/year (heat only)



Buildings' energy consumption in the industrial sector (MWh/ year)	280,000 MWh/year (heat only)
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Source: estimates by dena, 2017 and Abgeordnetenhaus Berlin

2.2.2 Key Heating and Cooling policy and legislation

2.2.2.1 Federal policy / legislation

2.2.2.1.1 Combined Heat and Power Act (KWKG)

Combined heat and power plays an important role in achieving Germany's emission reduction goals. In order to increase efficiency in the area of electricity and heat generation, the German Federal Government supports the expansion of combined heat and power, which is regulated in the [Combined Heat and Power Act \(KWKG\)](#). In addition to the electricity tariff for CHP plants and the promotion of heat and cold storage, the KWKG also includes support for investments in heating and cooling networks.

The maximum amount of funding per project is 20 million euros. At least 75% of the heat supplied to consumers connected to a new or upgraded heat network has to come from CHP. Alternatively, support applies if 50% of the supplied heat comes from a mix of CHP and renewables or CHP and industrial waste heat if within these 50% the part of CHP accounts for at least 25%. The required quota must be reached within 36 months from the commissioning of the heating network. CHP plants that are connected to existing heat networks are also eligible for support.

2.2.2.1.2 Heating network systems 4.0 (model projects)

The "[model project heating network systems 4.0](#)" is Germany's first promotion scheme where an entire system is being supported rather than just single components or technologies. In order to be eligible for funding these heat networks need to run on lower temperatures or a higher share of renewables or use waste heat in a particularly efficient way compared to conventional networks. Subsidies amount up to 600,000 euros for feasibility studies and up to 15 million euros for the realisation of a 4.0 heating network system.

2.2.2.1.3 KfW energy efficiency program - waste heat

Waste heat recovery and utilisation projects by commercial enterprises are promoted through investment subsidies as part of the "[push towards waste heat recovery](#)" programme in the National Energy Efficiency Action Plan (NAPE). This programme supports Investments in the modernisation, expansion or new construction of plants that either prevent or use waste heat (e.g. if waste heat is being fed into an existing heat network, the pipes leading up to the connection point are eligible for funding).

2.2.2.1.4 KfW Market Incentive Program

As part of the Market Incentive Program (MAP), the [Kreditanstalt für Wiederaufbau \(KfW\)](#) supports investments for using heat from renewable energies. The KfW "Renewable Energies Premium" programme supports, among other things, the construction and expansion of heat



networks, including the construction of substations, if the main source of heat generation is renewable.

2.2.2.2 Policy /legislation in Berlin

The [Berlin Information Center \(BIK\)](#) is the main platform to give an overview of the diverse climate protection activities in the city.

Berlin's overarching objective is to become CO₂ neutral by 2050. The pathway on how to achieve this is being developed and defined in the Berlin Energy and Climate Protection Programme 2030.

2.2.2.2.1 Berlin Energy and Climate Protection Programme 2030

Berlin's climate and energy objectives are legally defined in its [Berlin Energy and Climate Protection Programme 2030 \(BEK 2030\)](#) which was passed by the Berlin Senate in June 2017. The BEK is currently in the House of Representatives for consultation and its final approval is expected for early 2018. The BEK is looking at implementing an integrated approach to climate protection and energy and includes about 100 measures in the fields of climate protection and, climate change adaptation. The main focus of these measures lies on the efficient use of electricity, heat and fuels as well as an increased energy generation from renewable energies. In accordance with the *Berlin Energy Transition Law (EWG Bln)*, the implementation of the BEK is to be evaluated scientifically on a regular basis and updates will be made where needed.

2.2.2.2.2 Berlin Energy Transition Law (EWG Bln) of 22 March 2016

In April 2016 the Berlin Energy Transition Law (EWG Bln) entered into force. It sets the city's climate protection targets and stipulates that the Senate of Berlin had to develop the BEK with concrete measures and programmes to achieve these targets. At the same time, the law aims at contributing to international, European and national efforts to mitigate climate change.

Berlin's climate goals

Berlin set the target of reducing its CO₂ emissions by at least 40% by 2020, by at least 60% by 2030 and by at least 85% by 2050 compared 1990. In addition, all other greenhouse gas emissions are to be reduced in a comparable manner.

Establishment of climate-friendly energy generation and supply

The Senate of Berlin strives for a secure, affordable and climate-friendly supply of electricity and heat, which shall increasingly be based on renewable energies. Energy production from lignite will be ceased by the end of December 2017 and from hard coal by 2030.

The Senate supports research, demonstration and development of production capacities with regard to the expansion of renewable energies and high-efficiency cogeneration plants, as well as the increase of energy efficiency. It also supports options to make energy supply systems more flexible, including the development and use of storage technologies and smart grids.



The Senate of Berlin developed strategies and measures for the gradual reduction of heat demand in the building sector in the BEK 2030, taking into account potential savings and future heating requirements.

The Senate is furthermore committed to implementing the energy transition in Germany at the federal level. In doing so, it needs to take into account the costs of energy production and its fair distribution in society.

Increased generation and use of renewable energies

The federal State of Berlin aims at increasing the generation and use of renewable energies in public buildings and other public areas. Roofs of public buildings suitable for the production and use of renewable energy shall be used for the installation of solar or thermal energy generating facilities, if not contrary to public law.

District heating – connection

According to the amendment to the [EWG Bln](#) by Berlin's Parliament, which entered into force in November 2017 the Senate of Berlin is authorised to order a mandatory connection to heat networks in certain areas or order the mandatory use/consumption of heat from heat networks. This can be ordered for certain areas for resource and climate protection.

The obligation to connect and use shall be limited to newly build buildings. An exemption will be made if an area or building is already connected to a heating or cooling system that leads to significantly lower CO₂ emissions than what the district heating facility can provide. Another exemption can be made if the mandatory connection or use leads to social or economic hardship.

The ordinance can lay down specifications with regard to technological standards and the feed-in of renewable energies shall be made possible.

2.2.3 Heating and Cooling within urban development and renovation programmes

2.2.3.1 Heating and Cooling Objectives

Berlin's heating and cooling strategy is currently being formulated in the Berlin energy and climate protection plan.

Independently from this plan, Berlin committed to becoming coal free by 2030 the latest. Therefore Vattenfall and other partners, together with the government of Berlin, are working in a feasibility study to guarantee that the coal shift and the decarbonisation of the city's heat supply will be completed by 2030.

2.2.3.2 Energy Efficiency Opportunities

There is huge technical potential in realising energy efficiency opportunities through refurbishment in the city of Berlin. However, there are several factors limiting and hindering extensive refurbishment works and progress. Low fossil fuel prices have a huge impact on the economic viability of refurbishment projects. Furthermore, there is still a lack of social



acceptance and small-scale ownership structures can have a negative impact on refurbishment rates.

2.2.3.3 Renewable Energy Adoption and Potential

% renewable energies gross electricity consumption (2014)	2.2%
Share of renewable energies primary energy consumption (2014)	3.9%
Number of installed heat pumps (under MAP promotion scheme) (2016)	68
Renewable heat supply in district heating networks (2014)	468 m kWh

Source: [Föderal Erneuerbar, Bundesländer mit neuer Energie](#)

2.2.3.4 Transport and infrastructure

Public transport services in Berlin are offered in four different modes of transport: bus, tram, underground trains and city trains. The city trains are running on 100% renewable energy since December 2017. The electricity amount used by these trains amounts to 400 GWh (400 million kWh). Another area with a growing renewable electricity use is the power consumption for the train stations. Installed solar panels with a yearly production of 8000kWh and additional small wind turbines at Südkreuz, one of Berlins biggest stations, are the first steps in achieving electric self supply for train stations. For the bus system the carrier is aiming to increase electrification. The first bus lines are already operated only by electric busses and, according to the company's statement, have saved 150 tonnes of CO₂ emissions. (Renewable electricity efforts for tram and underground system are set to be reinforced in the future.)

2.2.4 Financing Opportunities and Instruments

Renewable energies are predominantly promoted by instruments at the federal level e.g. renewable energy law (EEG), KfW Market Incentive Program (MAP), etc.

The [Investitionsbank Berlin \(IBB\)](#) offers financing opportunities in the field of renewable energies, energy efficiency and climate protection. In addition to programmes for economic development, funding in the field of energy building refurbishment for private investors, housing companies or cooperatives is offered. IBB offers low-interest loans for landlords and investors to be used for new constructions, to purchase properties or for modernisation and refurbishment projects focusing on energy-related measures.



2.3 Stakeholder Identification and Engagement

2.3.1 Local stakeholders

2.3.1.1 Senate of Berlin

Berlin is governed by the [Senate of Berlin](#) consisting of the governing Mayor and up to ten senators. Since 2014 Michael Müller (social democrats) has been the mayor of Berlin, heading a coalition of social democrats, the left party and the greens, which was formed as a result of the election of the House of Representatives on 18 September 2016.

The Senate is divided into different administrations, which would be the equivalent of ministries on a national scale. These Senate administrations relevant for the THERMOS project are:

- Senate Department for Economics, Energy and Business
- Senate Department for Urban Development and Housing
- Senate Department for Environment, Transport and Climate Protection

2.3.1.2 Institute for Ecological Economy Research (IÖW)

The Institute for Ecological Economy Research ([IÖW](#)) was founded over 30 years ago with clients from the public and private sector and cooperations with international partners and clients such as the European Union or the United Nations Environment Programme (UNEP).

The IÖW was involved in preparing the feasibility study "Climate Neutral Berlin 2050", which was released in 2014. In 2015 a report with recommendations for the later adopted Berlin Energy and Climate Protection Programme 2030 was prepared on behalf of Berlin's Senate Department for Urban Development and the Environment.

Currently (June 2016 until May 2019) the research project "[Urban Heat Shift - Participatory Transformation of Coupled Infrastructures, Focusing on Heat Supply in Berlin](#)" supported by the German Federal Ministry of Education and Research (BMBF) is managed by IÖW as project leader. Cooperation partners are the Berlin Senate Department for Environment, Transport and Climate Protection, the Technical University of Berlin with the Department for Economic and Infrastructure Policy and the University of Bremen, Department for Resilient Energy Systems. The project Urban Heat Shift aims at developing an environmentally and socially acceptable heat supply in cities intelligently linking other infrastructures, such as gas and power. Different transforming options for the urban heat supply from various sustainable perspectives are being evaluated, using Berlin as a case study.

2.3.1.3 Wohnraumversorgung Berlin (WVB)

[Wohnraumversorgung Berlin \(WVB\)](#) is an unincorporated and private institution under public law in the state of Berlin, which provides advisory services to the Senate and the six state-owned housing companies (*Wohnungsbaugesellschaft Berlin-Mitte, Gesobau, GEWO BAG, HOWOGE, STADT UND LAND, Degewo*). The central task of the WVB is to formulate political guidelines for the implementation of the housing contract and the corporate structure and corporate governance of these housing companies. The WVB is a subordinate institution of the



Senate Department for Urban Development and the Environment. It was created by law on 1 January 2016 by the Berlin Housing Provision Act (WoVG Bln).

2.3.1.4 Degewo AG

[Degewo](#) is a German housing company based in Berlin, founded in 1924, that manages more than 70,000 apartments and 1,500 commercial units in Berlin.

2.3.1.5 GESOBAU AG

[GESOBAU AG](#), founded in 1900, is a housing association that belongs entirely to the State of Berlin and is one of the largest housing companies in Berlin and the whole of Germany. It provides homes for 100,000 people mainly in urban settings and neighbourhoods. As a municipal housing company, GESOBAU actively contributes to providing affordable housing for broad sections of the population in Berlin. Through new construction and purchase, it aims to expand its housing stock from the current 41,000 apartments to approximately 52,000 apartments by 2026.

2.3.1.6 GEWOBAG AG

With around 60,000 apartments and commercial properties, [GEWOBAG](#) manages around 100,000 tenants. Berlin is growing and in the last three years [GEWOBAG](#) has expanded its portfolio by around 8,200 apartments. In the medium term it plans to expand the portfolio by 14,600 apartments, including 10,200 apartments through new construction.

2.3.1.7 HOWOGE Wohnungsbaugesellschaft mbH

[HOWOGE](#) is an important municipal housing company in the state of Berlin with its own housing stock of around 59,000 apartments.

[HOWOGE](#) was the first German housing association to use air-water gas absorption pumps for the sustainable generation of heat as part of a flagship project. This allowed for gas consumption to be reduced by around 275,000 kWh a year. The reduction in carbon dioxide emissions is around 49 tonnes a year.

2.3.1.8 STADT UND LAND

[STADT UND LAND Wohnbauten-Gesellschaft mbH](#) is in charge of 43,300 apartments, more than 770 commercial units and manages about 13,400 rental units for third parties. The housing stock is expected to grow to a total of 55,500 apartments by 2026 through new construction and purchase. Since 2012, around 3,900 residential units have been purchased and around 1,900 new apartments are currently under construction. The company is also continuously investing in the refurbishment and modernisation of its properties, supporting numerous social projects and initiatives to strengthen neighbourhoods.

2.3.1.9 WBM Wohnungsbaugesellschaft Berlin-Mitte mbH

[WBM Wohnungsbaugesellschaft Berlin-Mitte mbH \(WBM\)](#) is the largest municipal real estate administrator in the inner-city of Berlin. 70% of the objects are prefabricated buildings. They include listed ensembles of the GDR post-war modernism and also the GDR standard multi-family house, so called "Platte".



2.3.1.10 BIM Berliner Immobilienmanagement GmbH

[BIM Berliner Immobilienmanagement GmbH \(BIM\)](#) emerged in 2015 from the merger of *Liegenschaftsfonds Berlin* and BIM. BIM is responsible for the letting, management, optimisation and sale of approximately 4,500 state-owned properties, on behalf of the State of Berlin. The State of Berlin uses around 1,600 buildings for its public administration. All of them are combined in the "Real Estate Assets of the State of Berlin" (SILB) and are managed by BIM on behalf of the State of Berlin.

2.3.1.11 Vattenfall Europe Wärme AG

Almost one third of apartments in Berlin are currently connected to district heating and use heat generated from [Vattenfall's](#) generation plants. Most of the district heating networks are located in densely populated inner-city areas. However, Vattenfall also supplies housing estates in suburban areas. If district heating pipelines are not located nearby, Vattenfall offers decentralised heating options. *Vattenfall Wärme AG* generates nearly 90% of its heat through combined heat and power. Small and large combined heat and power plants - from 100 kilowatts to 750 megawatts - form the core of Vattenfall's heat supply, which contains nearly 2,000 kilometres of pipelines, 18 pumping stations and 19,000 substations - Europe's third-largest district heating network after Moscow and Warsaw.

Climate protection agreement between Vattenfall and the State of Berlin

Vattenfall is working together with the State of Berlin to reach the objective of becoming carbon neutral by 2050. Measures that Vattenfall is implementing in order to achieve the agreed CO₂-savings are the modernisation its heating plants with regard to efficiency and lower emissions fuels, flexibility as well as the expansion of the district heating network and the construction of new combined heat and power plants.

In May 2017, the last lignite-fired power plant went off the grid. By 2030 the three hard coal power plants still in service are to be also closed.

By replacing conventional boilers with district heating each newly connected Berlin residential unit saves on average around one ton of CO₂ per year. Vattenfall's objective is to achieve a reduction in annual CO₂ emissions of a total of 200,000 tons in the Berlin heating market by 2020 through new connections to the district heating supply. Every year around 20,000 new apartments are connected to district heating.

Renewable energies and heat storage

Vattenfall has started to replace the hard-coal-fired block of the Reuter CHP plant in Berlin's district *Spandau* with Europe's largest power-to-heat plant, which will have a capacity of 120 MW_{th}. Vattenfall furthermore wants to use wind and solar power surpluses around the city to generate district heating. Heat storage systems will complete this combination for more flexibility.

Use of biomass



The biomass cogeneration plant "Märkisches Viertel" of Vattenfall, which was put into operation in 2014, generates heat and electricity from natural woodchips. In addition, two hot water generators produce district heating from natural gas. Furthermore, solid biomass is also used in co-incineration. In the coal-fired heating power plant Berlin Moabit natural biomass (woodchips) is used for combustion in larger quantities.

2.3.1.12 FHW Neukölln AG

In Berlin's district *Neukölln* the [FHW Neukölln AG](#), whose main shareholder is Vattenfall, supplies around 40,000 residential units in the *Neukölln* and *Kreuzberg* districts with heat. Berlin's largest heat storage system as of 2017 allows for the use of environmentally friendly combined heat and power (CHP) to generate electricity and heat. The heat storage also facilitates the integration of renewable electricity generation. If there is a lot of wind power in the grid in winter, connected CHP plants can be regulated down without endangering the heat supply. A power-to-heat system ("Electricity to District Heating") with a capacity of 10 MW_{th} in combination with the heat storage system is a highly flexible unit that contributes to the stability of the electricity grid by providing control power.

A 22-meter-high tank stores heat in form of 10,000 cubic meters of hot water for a time-delayed use for district heating. Due to the temporal decoupling of district heating production and supply, electricity can be produced even if there is low heat demand. Conversely, the heat supply is secured also without electricity production. This solution results from fluctuating electricity generation from wind power and photovoltaic plants in and around Berlin. In addition, the power-to-heat plant is a technical solution to integrate renewable energy into district heating. Operating like a giant immersion heater, it can convert excess electricity from renewable electricity generation into heat.

2.3.1.13 GASAG

[GASAG](#) is one of the oldest and biggest gas supply companies in Europe. Founded in 1847 it was originally responsible for providing gas for Berlin's gas lighting. In 1923 it was transformed into a stock company, which was completely owned by the city of Berlin. For the time that the city of Berlin was divided, GASAG was covering West Berlin. After the reunification in 1990 GASAG took over its Eastern counterpart BEAG.

It wasn't until 1993, that the Senate decided to sell its shares and privatisation was completed by 1998. After liberalising the German gas market the former monopolist GASAG lost customers to competition but is still the biggest gas supplying company in the Berlin area today. Today the shareholders are E.ON (36.85 %) and Vattenfall (31.575 %) and the internationally acting company Engie (31.575 %)- each owning around one third of the shares.

Today GASAG is also involved in innovative technologies and is driving forward the expansion of renewable energy. It set up products such as the virtual power plant "EcoPool", energy solutions for entire neighbourhoods and energy consulting. GASAG furthermore bundled its expertise in energy services at [GASAG Solution Plus GmbH](#). As of April 2017, the new subsidiary within the GASAG Group offers infrastructure and energy services for major projects such as



supplying the EUREF Campus, a 55,000 m² project area in Berlin promoting renewable city concepts, with district heating from a cogeneration plant. One of the projects in said area will also include GASAG implementing a power to heat/cooling plant.

2.3.1.14 BTB GmbH

[Blockheizkraftwerks- Träger- und Betreibergesellschaft mbH \(BTB\)](#) produces and supplies district heat mainly in East Berlin for apartments, industrial, and commercial properties. Examples are the scientific and business hubs in Berlin-*Adlershof* and the heating area further south in Berlin at the BBI Business Park at Berlin-Brandenburg International Airport. BTB's district heat is generated by more than 90% from combined heat and power. Another part comes from the use of renewable energies. Solar, wind and fuels such as wood and biogas are the main sources of energy.

2.3.1.15 Naturstrom AG

With its foundation as a stock company in 1998 [Naturstrom](#) became one of Germany's first independent providers of green electricity. Naturstrom has been growing continuously over the last 20 years. In 2009 they reached 50,000 customers and by 2016 that number grew to 260,000. The focus of Naturstrom's economic activity has been lying on power generation and trade. In 2009 Naturstrom expanded its business area to also include biogas generation and trade.

Since its beginnings the corporate identity has been to offer sustainable energy solutions, not only focusing on renewable energy sources, but also considering economic and social sustainability. The company's most recent approach is connecting energy generation and consumption and keeping both at a local level. This idea has been incorporated in projects for decentralised district solutions, which Naturstrom has started in the Berlin area. In these project districts Naturstrom is offering not only electricity but also heating and cooling options to the residents. In the 18,000 m² area of the [Holzmarkt](#) this will be achieved for example through combination of photovoltaics, geothermal energy and biogas. The energy supply is taking into account local circumstances e.g. using existing water tanks as heat storage.

2.3.2 National stakeholders

2.3.2.1 Federal Ministry for Economic Affairs and Energy (BMWi)

[BMWi](#) is the Federal Ministry for Economic Affairs and Energy in Germany. It was founded in 1949 together with the country of West Germany. First only concerned with economic affairs it added technology issues in 1998 and all energy related topics in 2013. In its current organisational structure two of ten departments are working on energy topics, one of those is the department "Heat and energy efficiency". In 2016 its share of the government budget contained 7.6 billion €.

The Ministry has several associated authorities. Most notable for are the Federal Office for Economic Affairs and Export Control (BAFA), Germany Trade and Invest (GTAI), Federal Network Agency (Bundesnetzagentur) and the Federal Cartel Office (Bundeskartellamt).



2.3.2.2 German Association of Energy and Water Industries (BDEW)

The German Association of Energy and Water Industries ([Bundesverband der Energie- und Wasserwirtschaft- BDEW](#)) represents companies active in the field of natural gas, electricity and district heat, water and wastewater (BDEW represents 1,800 companies). The companies differ widely in terms of their sizes and forms of organisation. The spectrum of the Association's members ranges from local and municipal utilities to regional and inter-regional suppliers. The companies of the energy and water industry supply electricity and water to almost all 40 million households in Germany. Furthermore, about 20 million German households are supplied with natural gas and five million with district heat.

BDEW was founded in autumn 2007 to combine the competencies of five different associations. BDEW is the main point of contact on all issues relating to natural gas, electricity, district heat as well as water and wastewater.

2.3.2.3 Energy Efficiency Association for Heat, Cooling and CHP (AGFW)

The Energy Efficiency Association for Heat, Cooling and CHP ([AGFW](#)) is an association of companies that operate CHP plants and district heating networks in Germany. The association sees it as its task to support the member companies through industry lobby in the fields of politics, law, technology, business administration as well as organisation and work safety.

The association is a consortium of more than 500 companies supplying heat or cold. These companies operate over 1,300 networks with a total length of 19,100 km. More than 80% of the heat is generated in combined heat and power plants. The same plants also supply about 7% of the German gross electricity generation. The heat input in Germany is around 57,000 MW. Of these, over 53,000 MW are statistically recorded by AGFW.

2.3.2.4 Verband kommunaler Unternehmen (VKU)

The [Verband kommunaler Unternehmen e.V. \(VKU\)](#) is the German Association of Local Utilities of municipally determined infrastructure undertakings and economic enterprises. These are companies, which provide services of general interest in Germany within the framework of local self-government. Therefore the VKU members do not primarily pursue private commercial objectives but are guided by public welfare obligations. They operate under local self-administration to serve "citizen value", i.e. to meet the needs of the local community. The type of capital they form and secure is a community-oriented asset (Resolution of the VKU Executive Committee of 26 February 2008).

The VKU represents the interests of the local public utility sector in Germany, which includes energy and water supply as well as disposal services. With its nearly 1,500 member companies it employs over 260,000 people, generating a combined revenue of 115 billion €.

2.3.2.5 German Association of Towns and Municipalities (DStGB)

The German Association of Towns and Municipalities ([Deutsche Städte- und Gemeindebund - DStGB](#)) represents the interests of the German cities and communities. At the provincial, federal and EU level, they form the representation of interests and address the issues of local citizens.



17 different associations with 11,000 large, medium and small municipalities are united in the DStGB. The DStGB works independent of parties and without state subsidies.

The German Association of Towns and Municipalities works as:

- special interest group for municipal representations
- information network
- coordinating committee

2.3.2.6 Association of German Cities

The Association of German Cities ([Deutscher Städtetag](#)) is advocating the opinion of cities and the national local-authority association of cities. As the interest group of cities it represents the idea of local self-government to Federal Government, Federal States (Bundesländer), European Union, governmental and non-governmental organisations. The work and services of the Association of German Cities are primarily geared to the needs and interests of the direct member cities and their citizens.

2.3.2.7 Ifeu Institute

The ecological research institute [ifeu](#) is operating research projects and providing consultancy service worldwide in relation to all major environmental and sustainability issues. Ifeu is part of an interdisciplinary research network. Their team is working with state of the art modelling tools.

The approach to current research topics aims to integrate practical and societal aspects. An efficient energy system primarily based on renewable energy requires efforts and measures across all sectors, i.e. for electricity supply and demand, the heat market, the transport sector, but also in the context of societal change. Ifeu currently employs 80 staff members in Heidelberg and Berlin.

2.3.2.8 Institute for housing and environment (IWU)

The [Institut Wohnen und Umwelt GmbH \(IWU\)](#) - institute for housing and environment - is a non-profit research institute. The institute is working on both basic and applied research, with an emphasis on interdisciplinary work. In 1971, the work in Darmstadt was taken up on housing policy and urban development issues. Since 1985, the institute is also doing research on the rational use of energy in buildings.

The institute has three fields of research in which different projects are assigned. The research field *housing* focuses on topics concerning housing supply, housing industry, city development and mobility research. The research field *energy* has its emphasis on the efficient use of energy in buildings. The research field *integrated sustainable development* is composed of interdisciplinary projects on different levels of space, e.g. city / region, neighbourhood and building.



2.3.3 Existing stakeholder participation processes

2.3.3.1 Innovation Center Energy of the TU Berlin

[The Innovation Center Energy \(IZE\)](#) bundles and brings together the activities of the Technical University Berlin in the field of energy research. It links the expertise of the IZE with energy and provides a central platform for communication and collaboration with industrial and external research partners. The IZE promotes and supports junior researchers in the field of energy and strengthens and integrates energy research in the capital region Berlin / Brandenburg.

2.3.3.2 Berlin 21 e.V. network

[Berlin 21 e.V.](#) is an association that supports and promotes innovative project approaches and learning processes by bringing together actors from various areas of society on key issues such as sustainable energy. As part of the Berlin 21 e.V. network, various interest groups work together to promote the sustainable development of the city region.

2.3.3.3 Network natural gas Berlin-Brandenburg

Network natural gas ([Network Erdgas](#)) is a platform that brings together stakeholders from Berlin and Brandenburg who are active in the natural gas sector.

2.3.3.4 Cluster Energietechnik Berlin-Brandenburg

The two federal States Berlin and Brandenburg created the [Cluster Energietechnik Berlin-Brandenburg](#) in 2011.

With more than 6,000 companies and over 56,000 employees the Cluster aims at contributing to and supporting the transnational innovation potential around the core topics of renewable energy, energy efficiency, networks & storage as well as turbomachinery and power plant technology.

2.3.3.5 Berlin NetworkE

In this network, companies are working together on topics related to energy efficiency and renewable energies. The network management lies with the Berlin Energy Agency. The [Berliner NetzwerkE](#) sees itself as part of the Smart City strategy of the state of Berlin and focuses on practice-oriented solutions for the interaction of people and technologies in the field of energy management. The network partners jointly develop innovative concepts, products and services for more energy efficiency and implement them in model projects. Since the end of 2008, more than 20 model projects in the field of energy efficiency and renewable energies have been launched with the help of the Berliner NetzwerkE network.

Over the past nine years, the Senate Department for Economics, Energy and Enterprises has been funding the network through the Joint Task "Improving Regional Economic Structure". Members of the board are, amongst others, from Berliner Immobilienmanagement GmbH (BIM), Berliner Stadtreinigung (BSR), GASAG, HOWOGE, Vattenfall and WISTA MANAGEMENT GMBH.



2.3.4 THERMOS Local Liaison Group

2.3.4.1 Stakeholder roles towards THERMOS model replication

Local Liaison Group		
Name of Organisation	Type of stakeholder	Role within LLG
Senate of Berlin	Public administration	<ul style="list-style-type: none"> • stakeholder engagement • testing the THERMOS tool in the context of current policy developments or programmes in Berlin. Urban planning tools such as the THERMOS software could be key to meeting the goals of decarbonisation in Berlin.
Institute for Ecological Economy Research (IÖW)	science and research institution	<ul style="list-style-type: none"> • stakeholder engagement • further THERMOS trainer • testing the prototype THERMOS software at up to three potentially sites in Berlin for district heating development in 2018 • dissemination of the THERMOS tool
Naturstrom AG	utility	<ul style="list-style-type: none"> • testing the prototype THERMOS software at a potentially Berlin-site for district heating development in 2018 • dissemination of the THERMOS tool
GASAG Solution Plus GmbH	Energy service provider	<ul style="list-style-type: none"> • testing the prototype THERMOS at a potentially site for district heating development in 2018



		<ul style="list-style-type: none">• dissemination of the THERMOS tool
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2.3.5 Stakeholder Engagement Strategies

The Berlin Senate is interested in testing the THERMOS tool in the context of current energy and climate policy developments or programmes in Berlin (further policy development e.g. the BEK 2030 is described above) and is potentially able to assist in maximising the THERMOS project's impact at European level through existing international networks of the city.

The Institute for Ecological Economy Research (IÖW) is interested in testing the prototype THERMOS tool at up to three potentially sites for local district heating development in 2018 and is potentially able to increase stakeholder engagement. Using and testing the THERMOS prototype may support the planning of potential district heating solutions at the three sites in Berlin and would also contribute to additional developments in the project "Urban Heat Shift - Participatory Transformation of Coupled Infrastructures, Focusing on Heat Supply in Berlin".

Naturstrom AG is interested in testing the prototype THERMOS tool at one potentially site for a local district heating network solution within their project portfolio in Berlin in 2018 and is potentially be able to assist the dissemination of the THERMOS tool at national level.

GASAG Solution Plus GmbH is interested in testing the prototype THERMOS tool at one potentially site for a local district heating solution in 2018.

2.4 Towards THERMOS Uptake

2.4.1 Barriers

One barrier to the uptake of THERMOS in Berlin is the fact that the Berlin Energy and Climate Protection Programme 2030 (BEK) is still in the final political consultation rounds. This means that concrete measurements for increased efficiency and a larger share of renewable energies and the prioritisation of them is still missing.

Furthermore, the heat network in Berlin is owned in large parts by Vattenfall. Even though the Senate of Berlin is working on a feasibility study on exiting coal by 2030 together with Vattenfall, it will still take some time for concrete measures to be implemented. The supporting work that the THERMOS tool can play in this endeavour will therefore be pushed back.

2.4.2 Proposed solutions

The aim is to work very closely with the Berlin local liaison group and guarantee that as soon as the next steps in communal heat planning are being taken, THERMOS will be used as a supporting tool.

2.4.3 THERMOS exploitation opportunities

In Berlin, opportunities for the application of the THERMOS tool are within projects of the local liaison group. Existing members of the Local Liaison Group like Naturstrom AG and GASAG



Solution Plus GmbH can use the THERMOS tool within their project pipeline in Berlin and intent to continue using it after the test phase throughout Germany.

2.5 THERMOS Case Study

2.5.1 Objectives

The THERMOS case study in Berlin will consist in a “confirmation/reality check”. Real planning data coming from a heating network currently under construction by GASAG Solution Plus GmbH will be compared with the results of the THERMOS tool. The foreseen heating network will supply heat to an entirely new residential neighbourhood.

This check will generate valuable feedback for the results of the THERMOS tool. The following central question about the tool will be answered: are the results from the THERMOS tool similar to those of other planning tools that are already in use? What are the main similarities and differences? In addition to testing the planning data results of THERMOS, further tests regarding operating data of the given heating network will be undertaken.

A final decision concerning the timeframe of the testing of the THERMOS tool in 2018 will be taken in the next months, once the THERMOS tool is developed.