Evaluation plan for Federal support for efficient heat networks (BEW) as part of the notification under state aid rules under KUEBLL

State of play: 02.05.2022

Content

1. Introduction

The Federal Government has set itself the objective of achieving net greenhouse gas neutrality by 2045 at the latest. In doing so, Germany is making an important contribution to the EU's 2050 climate neutrality objective. The key to this is to make Germany's energy and heat supply neutral in greenhouse gas emissions by 2045. For this purpose, the objective of increasing the expansion of renewable energy and waste heat in heating and cooling networks was already laid down in the first National Energy and Climate Plan of the Federal Republic of Germany: A target of 25 % by 2025; 30 % by 2030. The coalition agreement of the current federal government sets even more ambitious targets for the heating sector. A 50 % share of renewable energy and waste heat in heating networks is targeted for 2030.

The Guidelines for Federal Support for Efficient Heat Networks (BEW) are expected to make an important contribution to this. The aim of this support is to stimulate investments that increase the share of renewable energy (RES) and waste heat in heating networks in Germany, thereby reducing greenhouse gas emissions. To this end, support will be given to the construction of new heating networks with high shares of renewable energy and waste heat, as well as to the expansion and transformation of existing networks with the objective of climate neutrality in 2045.

The BEW support follows a systemic approach that focuses on the heat network as a whole and aims to provide predictable and reliable support for the time-consuming conversion of existing networks to renewable energy and waste heat and the construction of mainly renewable fed networks on the basis of transformation plans. This systemic approach will be complemented by individual measures at the appropriate place. The support follows a comprehensive approach to network size, taking into account both small, medium and large heat networks.

The purpose of this document is to plan the parallel and thorough evaluation of the Directive in order to determine whether and to what extent the original objectives are being achieved and what impact the scheme has had on markets and competition.

The first step is to present a schematic presentation of the intervention logic in order to illustrate the mechanism of action of the Directive. It then lists the evaluation questions divided into direct and indirect impacts, as well as appropriateness and appropriateness. The table shows in parallel the related result indicators, data sources, their frequency and level and the evaluation methodology.

The following sections present the data sources to be used for the evaluation and the timing. It also explains in detail the methodology used for the evaluation, examining the possibilities for identifying causal effects and discussing further methodological approaches on specific issues.

Further information on the planning of the evaluation can be found in the questionnaire.

2 Intervention logic

In order to understand the mechanism of action of the BUE and its consequences, the following breaks down Table 2-1 the chain of action of the BEW from input to impact. The BEW support covers networks to which more than 16 buildings or more than 100 housing units are connected. The 2022 Budget Law is not yet in force due to the 2021 Bundestag elections. The agreed version of the Funding Guidelines assumes that, when the 2021 and 1st budget estimates are updated. Government draft 2022, including financial programming, has a total financial volume of EUR 3.1 billion available for the BEW. These resources would be used to achieve the effects set out in Table 2-1 2. The Federal Government proposes to the Parliament the 2nd Government's draft 2022 budget will increase to around EUR 790 million p.a. by 2025 (and could therefore have a larger impact). . However, funding is in principle subject to the availability of budgetary resources.

Table 2-1: Chain of action for the BEW

Input	Specification of the intervention(s)	Output/product	Outcome/result	Impact/Impact
• Grants for the preparation of transformation plans (stock networks) and feasibility studies (new networks) and planning services (module 1).	• Support for transformation plans and feasibility studies with 50 % of eligible costs (max. EUR 600 000 per study)	• Transformation plans and feasibility studies	• Plans describing the objective and pathway for the transformation of existing networks as a basis for investment measures • Studies describing feasibility, objectives and trajectories for new networks with a high share of RES and waste heat, as a basis for investment measures	**Direct effects with regard to:** Increasing renewable district heating production • Dissemination of RES technologies and their combination • Increasing the share of RES in heating networks (contributing to achieving the target for RES shares under RED) • Making the operation more flexible through heat reservoirs • Reducing the use of fossil fuels in order to reduce import dependency • Focused use of biomass in heat networks (quarterly monitoring planned to meet the sustainable potential and allowed full load hours) Cost-effectiveness of district heating • Proceeds from heat produced
• Subsidies for investment costs in the context of systemic support (Module 2). • Grants for investment costs for individual measures (module 3).	• Systemic support for new-build **networks (** in the case of at least 75 % renewable energy and waste heat and compliance with other criteria (4.2.1) and the existence of a feasibility	• Triggered investments in heat networks and heat generators (own share and grant) • Objective: EUR 690 million per year in heating	• Construction and construction of new heating networks • Construction and integration of renewable energy production plants and waste heat into heat networks (target: up to 400 MW of	

	study) and existing networks (if a transformation plan is available), each calculated on the basis of a gap in profitability, with a maximum of 40 % of the eligible expenditure for investment in generation facilities and infrastructure (max. EUR 100 million per application). • Support for individual measures with a maximum of 40 % of the eligible expenditure for investment in generation facilities and infrastructure (max. EUR 100 million per application).	networks. Size classes	renewable heat production per year by 2030) • Renovation of the heating networks to integrate RES (measures to increase efficiency and reduce the temperature of the grids) • Increasing flexibility in the energy system through heat storage and heat pumps	• Maintaining the competitiveness of district heating with an increasing share of RES and waste heat • District heating prices for end-users remain competitive • Increased heat supply to buildings and processes via heat grids • Construction of new heating networks • Development of existing networks **Indirect effects:** Decarbonising heat production • Reduction of CO_2emission factor (contribution to CO_2reduction) • Investment incentives and attention for RES production systems and heating networks Increasing efficiency • Saving fossil primary energy by changing energy sources to RES and waste heat • Reduction of network losses • Reduced RES regulations in the electricity system through electricity integration into heat generation + heat storage Other effects • Employment effects from construction, installation and maintenance of generating installations and heat networks • Supply via heating networks becomes more attractive in the new building sector by decreasing primary energy factors
• Operating grant for solar thermal and heat pumps feeding into heat networks, both in new and existing networks.	• Operating support for production from solar thermal installations (1 Ct/kWh_{th}) and heat pumps with SCOP of at least 2.5 (max. 9.2 $ct/kWh_{ambient\ heat}$ (grid electricity) or 3 ct/kWh_{th} (direct connection RES-E), depending on SCOP) (if supplied to heat networks); limited to the	• Production of RES heat from solar thermal and heat pumps	• Higher share of RES in heating networks	

	profitability gap (annual proof required)	(PEFs) and thus TPEFs in the buildings, in order to comply with legal requirements (GEG) • Increased demand for craftsman's services prolongs conversion processes and increases costs • Public dissatisfaction due to significant road construction (pipeline construction) •

Source: Own presentation

3 Evaluation questions and result indicators

Table 3-1: Evaluation questions and result indicators

	Evaluation question	Result indicator	Data source	Frequency	Level	Evaluation methodology
	Direct impact					
1.1	• How has the share of RES and waste heat developed in heating networks in DE? • Is it expected that the increase of at least 1 percentage point per year will be achieved by 2030 in accordance with RED Article 24(4)? • How has the share of RES and waste heat developed in supported heat networks?	• Share of RES in heating networks in Germany • Increase in RES share in percentage point/year • Share of renewable energy in supported heat networks	• BMWK-EE in figures (Table 2) • 066+ 064 of the StBA supplemented by the BHKW survey of the Öko-Institut and AGEE-Stat • BAFA: Proof of use and progress report	• Annual	• Federal Governm ent • Heat network	• Descriptive statistics • comparative analyses • Model-supported ex-ante analysis

	• What is the causal effect of BEW support on observed developments?		• Heat grid register			
1.2	• How has the renewable heat production output developed in heating networks in DE? • How much renewable heat production has been supported per year? Does this correspond to the target of an average of 400 MW per year? • How much has been built outside the funding? • What is the causal effect of BEW support on observed developments?	• Renewable heat production in heat networks • Supported renewable heat production in MWth per year • Unsupported construction as a difference from statistics and support	• 066+ 064 (Table 1.1) of the StBA • BAFA: Applications for funding	• Annual	• Federal Government	• Descriptive statistics • Analysis
1.3	• What is the level of investment triggered by the support, corresponding to the planned average of around EUR 690 million? • What investments were made outside the support in heating networks?	• BEW support and investment volume triggered in euro per year (see question 1.11) • Investments in heating networks outside BEW support	• BAFA: Applications for support and proof of use • Research into data sources for investments not funded or supported by other support programmes (KWKG, Land funding programmes and heat network register)	• Annual	• Federal Government	• Descriptive statistics
1.4	• What has been the $CO2_{savings}$per year so far? Will the planned savings of 2.4 million tonnes of CO_2 per year be achieved in 2030?	• CO_2— Savings through implemented measure per year	• BAFA: Proof of use and interim statements • Quantitative and qualitative discussion • Ex-post statistics • Ex-ante modelling	• Annual	• Federal Government	• Quantitative analysis bottom-up on counterfactual cases • Ex-ante top-down analysis by modelling

1.5	• How many actors have been reached, how many are this compared to the total amount?	• Number of actors receiving funding • All actors in the field of eligible heat networks	• BAFA: Support statistics, classification where applicable (enterprises, cooperatives, municipalities) • EBFW Data • StBA 064+ 066	• Annual	• Federal Governme nt	• Descriptive statistics
1.6	• Have heat networks been addressed in all size classes?	• Aid cases/size class of heat networks	• BAFA: Support statistics, classification of path length by small, medium-sized, large networks (up to 20, 20-50, over 50, over 100) • Reconciliation with 064 of the StBA, Table 1.3	• Annual	• Federal Governme nt	• Descriptive statistics
1.7	• Were the supported measures distributed equally via the Federal Republic of Germany? • Has the objective of integrating renewable heat throughout Germany into existing and newly built heat networks been achieved?	• Measures supported/Bundesland	• BAFA: Funding applications (location of investment, classification by Land, size class of municipality)	• Annual	• Federal States	• Descriptive statistics
1.8	• Is heat production and grid operation competitive in economic and price terms compared to other options for the supply of heat produced in a sustainable or renewable manner?	• Heat-level costs	• BAFA funding applications/use-of-use and cost-effectiveness gap calculation (heat level costs as declared by	• Annual	• Federal Governme nt	• Empirical analysis of BAFA information • Comparison with a general

			the applicants), see questions 3.2 and 3.3 • Energy analysis			energy-economic perspective
1.9	• Has the combination of different RES production technologies been initiated and the integration of waste heat into new and existing heat networks? • What is the causal effect of BEW support on observed developments?	• Number of generation technologies/heat grid	• BAFA funding applications • General analysis of the structure of heat networks to differentiate the supported/unsubsidised heat networks	• Timing of the overall evaluation	• Federal Government	• Empirical analysis of BAFA information • Comparison by search/survey of operators and associations
1.10	• How has the number, length and temperature level of heat networks evolved? • What train lengths have been supported by the BEW? • What is the causal effect of BEW support on observed developments?	• Evolution of the number and length of heat networks, differentiated according to existing and newly built networks • Aided path length • Evolution of temperature level	• 064 of the StBA, Table 1.3 • BAFA: Applications for funding and proof of use • Analysis of the profitability gap calculation for investments	• Annual	• Federal Government	• Descriptive statistics • Counterfactual case analysis
1.11	• How many transformation plans and feasibility studies have been supported? • How many systemic support and individual measures have been granted (type, scope, state of implementation)? • What are the amounts of support granted in each case and the related triggered investments per year? • What is the level of unsubsidised heat network investment?	• Number of transformation plans, feasibility studies and level of planning services • Number of systemic subsidies by species • Number of individual actions supported by type • Support granted per year by type • Investments triggered per year by type	• BAFA: Funding statistics • StBA: 064 Table 1.5 Heat reservoirs by power and number • Research into data sources for investments not funded or supported by other support programmes (KWKG, Land funding	• Annual	• Federal Government	• Descriptive statistics

			programmes and heat network register)			
1.12	• How many applications for operating support were submitted, and how many were granted for solar thermal and heat pumps (electricity from grid/non-conducted electricity)? How much was the support granted, how did it change over the years in terms of amount and number? • What is the total annual operating grant?	• Support by technology in ct/kWh in the different years • Total operating support per year in Euro and in Euro/kWh	• BAFA: Annual monitoring of operating costs and interim statements	• Annual	• Federal Government	• Descriptive statistics
1.13	• What are the external circumstances that hinder or facilitate the achievement of the objectives?	• Qualitative statements on the operation and economic viability of heating networks and the integration of renewable energy sources	• BAFA: Analysis of requests for operating costs • General energy statistics • Industry literature and expert interviews	• Annual	• Federal Government	• Qualitative statements, expert interviews supported by quantitative analyses
1.14	• Are the sustainably available biomass potential limits respected? • Is it to be expected that the share of biomass in the annual production of 25 % will not be exceeded in the third year following the entry into force of the Directive?	• Quantities of biomass used in supported heat networks • Quantities of biomass used in all heat networks	• BAFA funding applications • Federal Environmental Agency (UBA) • German Biomass Research Centre (DBFZ)	• ¼ annual	• Federal Government	• Analysis of BAFA information and other data sources • Comparison with current potential recommendations
	Indirect impact					
2.1	• How has the share of losses developed in heat networks? • What is the causal effect of BEW support on observed developments?	• Share of losses (heat production minus heat discharge from heat production)	• BMWi Energy data Table 25 'Resources and use of district heating'	• Annual	• Federal Government	• Descriptive statistics

			• EBFW Main Report			
2.2	• How has the energy mix developed in heating networks? • What is the causal effect of BEW support on observed developments?	• Energy mix (absolute and relative) for lignite, coal, natural gas, electricity, solar thermal, environmental heat, geothermal, biomass, waste heat...	• BMWi Energy data Table 25 'Resources and use of district heating' • StBA 066+ 064 • Working Group Energy Balance for Heating Plants • EBFW Main Report	• Annual	• Federal Governme nt	• Descriptive statistics
2.3	• How has the primary energy factor developed in the subsidised networks and on the national average? • What is the causal effect of BEW support on observed developments?	• Primary energy factor in supported heat networks • Average primary energy factor in heat networks	• BAFA: Evidence of use and progress reports • EBFW Main Report	• Timing of the overall evaluatio n	• Federal Governme nt	• Descriptive statistics
2.4	• How has the CO2 emission factor developed for district heating production? • What is the causal effect of BEW support on observed developments?	• Specific CO_2 emissions (unit g $CO_{2/kWh}$ heat)	• Derived from 2.2 • EBFW Main Report	• Annual	• Federal Governme nt	• Descriptive statistics
2.5	• What are the specific CO_2 reduction costs in the funding cases, how much is the share of support?	• Euro/t reduced CO_2 emissions	• Derived from 2.3+ 2.4 • BAFA: Applications for funding	• Annual	• Federal Governme nt	• Quantitative analysis • Comparison with counterfactual cases
2.6	• How have the investment costs per metre heat network developed (by diameter)?	• Euro/m heat network (by diameter)	• BAFA: Funding statistics	• Annual	• Federal Governme nt	• Quantitative analysis • Stakeholder interviews
2.7	• Does the BEW support have an impact on the development of the	• Time series on investment costs/production techology	• BAFA: Applications for funding • Expert interviews	• Timing of the overall	• Federal Governme nt	• Qualitative statements supported by

		availability of generation technologies?	• Evolution of delivery times		evaluatio n		quantitative analyses and expert interviews
2.8	•	Has there been any negative impact on the heat or electricity market as a result of the support from the BEW?	• Evolution of heat delivery costs of different generation technologies	• BAFA: Interim Evidence and Progress Reports • Stakeholder interviews	• Timing of the overall evaluatio n	• Federal Governme nt	• Qualitative statements supported by stakeholder interviews
2.9	•	Does the BEW support have an impact on the competitive situation in the heat market and possibly also in the electricity market?	• Comparison of concentration measures (HHI, CR) in selected urban heating and electricity networks	• Heat grid register	• Timing of the overall evaluatio n	• Regional considerati on of individual heat networks	• Qualitative assessments substantiated by quantitative analyses
2.10	•	What is the impact of the support of heat networks and storage under the BEW on their support under the KWKG	• Number and length of supported heat networks under BEW and CHPG	• BAFA: Funding statistics	• Annual	• Federal Governme nt	• Quantitative analysis • Stakeholder interviews
	Appropriateness and appropriateness						
3.1	•	Was investment support for heating networks and production systems adequate? • How has the economic viability of the supported heat networks evolved in a changing market environment?	• Evolution of heat supply costs by type of production • Evolution of heat costs for final consumers of district heating	• BAFA: Funding statistics: Economic gap calculation for systemic support	• Timing of the overall evaluatio n	• Federal Governme nt	• Qualitative analysis using the answers above, in particular 2.5, 2.6
3.2	•	Have applications for operating support been rejected on the basis of the gap calculations?	• Number of rejected applications	• BAFA: Funding statistics: Gap calculation for operating support	• Annual	• Federal Governme nt	• Quantitative analysis

3.3	• What are the efficiency gaps identified in the applications for systemic support and individual action funding and in the interim operating grant statements? • What are the counterfactual cases identified in the applications and supporting documents?	• Economic gaps in ct/kWh$_{th}$ • Description and aggregation of the counterfactual cases mentioned above	• BAFA: Applications and interim proofs	• Annual	• Federal Government	• Quantitative analysis
3.4	• Is it expected that the objectives of the BEW will be achieved with the current funding design?	• Evolution of target parameters (see above)	• Results of 1.1 (RES shares), 1.2 (EE heat output), 1.3 (investments), 1.4 ($CO_{2\ savings}$) and 1.13 (general influencing factors)	• Timing of the overall evaluation	• Federal Government	• Qualitative analysis based on quantitative results
3.5	• Are the heat networks developed along the transformation plans or have deviations from the trajectory been reported? • What are the justifications for the deviations? • Will reimbursements of the support be accepted?	• Notifications of deviations	• BAFA: Funding statistics/annual confirmation of compliance with the criteria for new networks.	• Annual	• Federal Government	• Descriptive statistics
3.6	• What are the implementation rates and times of the respective supported actions	• Implementation rates per production segment • Non-realisation of quantities awarded • Implementation time per production segment	• BAFA: Funding statistics	• Annual	• Federal Government	• Quantitative analysis of the difference between authorisation and IBN
3.7	• Was investment and operating support the best funding approach?	• Theoretical considerations to compare with other	• Assessment matrix • Expert assessment	• Timing of the overall	• Federal Government	• Qualitative assessments substantiated by

	• Would be supported by other funding schemes (e.g. Taxes, calls for tenders, other instruments) have been able to achieve more efficient results?	potential support instruments	• Consideration of heat network support in selected other Member States	evaluatio n		quantitative analyses
3.8	• Should the minimum share for renewable energy and waste heat in the construction of new heat networks be increased as an eligibility criterion or should the further eligibility criteria (section 4.2.1) be adapted for new heat networks?	• Number and length of new heat networks supported by BEW and unsubsidised/cogeneratio n supported • RES share and other characteristics of new and unsubsidised networks	• BAFA: Bew and KWKG Promotion statistics • Heat grid register/Research of new heat networks	• Timing of the overall evaluatio n	• Federal Governme nt	• Quantitative analysis
3.9	• Should an efficiency criterion be applied to all systemic support?	• RES share and other characteristics of existing networks (supported and unsubsidised)	• BAFA: Bew and KWKG Promotion statistics • Heat grid register/Research of new heat networks	• Timing of the overall evaluatio n	• Federal Governme nt • Heat network	• Qualitative analysis based on descriptive statistics
3.10	• Is the operating support appropriate or should it be reduced in order to be able to support more heat networks if necessary? • How has the profitability of the supported plants evolved in a changing market environment?	• Economic viability of counterfactual case designs (or typed heat generator technologies) by LCOE analysis • Discussion of alternative options and their costs	• BAFA: Interim statements of evidence • General energy statistics • Assumptions on the development of electricity and heat market parameters	• Annual	• Federal Governme nt • typed installation s	• Qualitative statements supported by quantitative analyses (parameter analysis)
3.11	• Should operating support for deep geothermal energy be introduced?	• Profitability analysis by LCOE analysis	• General energy statistics • Assumptions on the development of	• Annual	• Federal Governme nt	• Qualitative statements supported by quantitative

		• Discussion of alternative options and their costs	electricity and heat market parameters		• typed installations	analyses (parameter analysis)
3.12	• How have the realised annual labour figures for the supported heat pumps evolved in comparison with unproduced heat pumps	• Realised annual labour figures for supported heat pumps and average nationwide	• BAFA: Interim Evidence/Progress Reports • General energy data	• Annual	• Federal Government	• Quantitative analysis

4 Data availability and collection

4.1 Competent authority (Federal Office for Economic Affairs and Export Control (BAFA))

4.1.1 BEW

Data collection on all supporting information for BEW is ensured by BAFA. To this end, appropriate funding statistics shall be drawn up and made publicly available. For the purposes of the evaluation, more detailed information will be collected electronically and made available to any contracted institutions, while respecting confidentiality requirements.

The information required for the evaluation shall be made available from the following sources:

- **Transformation plans and feasibility studies:** To be submitted after 12 (+ 12) months after authorisation.
- **Applications for funding:** To be submitted before the start of the project. Numerous evaluation-relevant content, in particular the calculation of the gap in profitability, with plausible counterfactual cases for systemic support and support for operating costs.
- **Proof of use**: To be submitted to the granting authority after the project is fully operational, but no later than three months after the end of the authorisation period. Authorisation period Module 1, see above; Module 2: 48 (+ 24) months, Module 3: 24 (+ 12) months.
- **Annual confirmation**: Annual reporting for newly built networks that the subsidised installation is operated in accordance with the minimum requirement for eligible networks
- **Interim statement**: Annual reporting for operating support
- **Progress report**: 10 years after commissioning
- **Annual monitoring of BAFA for the level of operating support**
- **Quarterly monitoring of support in the field of biomass installations** with data exchange between BAFA, Umweltbundesamt (UBA) and German Biomass Research Centre (DBFZ) in order to ensure compliance with EU law requirements under the NEC Directive

The funding statistics should be updated regularly and include a public compilation of information on applications, authorisations, proof of use, interim evidence and progress reports.

The results of BAFA’s annual monitoring of operating support and quarterly monitoring of support for biomass installations should be made available at least for evaluation purposes.

4.1.2 Combined Heat and Power Act (KWKG): Heat networks and storage facilities

The KWKG has supported heating and cooling networks and heat and cooling storage facilities since 2012. The following data are available to BAFA and can be used for evaluation purposes:

- Location of the installation
- Date of entry into service

    - Subsidy supplement
    - For networks:
        - Path length
        - Mean DN value
        - Type of measure (new construction/upgrading/network, reinforcement, connectivity, conversion)
        - Heat/cooling network
        - Heat rate
    - For memory:
        - Storage volume
        - Pressure storage factor
        - Average heat loss
        - Type of use (space heating/air conditioning, water heating, process heat/cold)
        - Heat/cooling reservoirs

4.2 Federal Statistical Office, Renewable Energy Statistics Working Group (AGEE-Stat) and BMWK Energy Data

The Federal Statistical Office (StBA) already collects and documents numerous indicators and parameters that enable the current stock of heat networks to be described in aggregated form. The aggregation refers to Germany from a spatial point of view, but the data are often also available at the level of the Länder. In terms of time, annual values for one calendar year are shown. The delay is usually between one and two years.

Important statistics for this context are:

- Annual survey on the production and use of heat and on the operation of heat networks (064)
    - Table 1.1+ 2.1: Number, net output, heat production, energy input and stock of heating plants by Land, location of company headquarters and plant
    - Table 1.2+ 2.2: Production of heat and electricity, use and stock of heat-controlled combined heat and power plants with a net rated electrical capacity of less than 1 MW electrically by federal state, location of the company's registered office and location of the plant
    - Table 1.3: Number and infrastructure of heat networks by main heat carriers used
    - Table 1.4: Heat balance
    - Table 1.5: Storage capacity of storage facilities
- Monthly survey of electricity and heat production for general supply (066)

  - Table 3.2: Net rated power of power plants by main energy sources
  - Table 4: Production of electricity and heat by energy carrier (total)
  - Table 5: Fuel input for electricity and heat generation by energy carrier (total)
  - Table 11: Supply of heat by group of customers
- Extraction, use and distribution of sewage gas (073)
- Production of heat and electricity from geothermal energy (062)
- AGEE-Stat: Time series on the development of renewable energy in Germany using data from the Renewable Energy Statistics Working Group
  - Table 2: Shares of renewable energy 1990 to 2020
  - Table 5.1: Renewable energy in district heating 2003 to 2020
- BMWK: Facts and figures: Energy data
  - Table 25 Supply and use of district heating

For a complete overview of district heating production statistics 064, 073, 062 and 066 should be combined. The latter is needed for the integration of heat produced in cogeneration. Other sources should be added for a complete overview, such as for the plants under 1 MW and biogenic plants, which are often not fully covered by the data of the StBA. These data can be supplemented by information from the CHP survey carried out by the Öko-Institut and the AGEE Stat, in line with the approach taken for the collection of CHP production.

Time series can ex-post show the development of heat networks for, inter alia, the following parameters:

- District heating production by energy source by number of installations and quantity of energy
- Share of RES in district heating production
- Share of district heating production per energy carrier
- CO_2 Emissions from district heating
- Network losses
- Number and length of heat networks per temperature level
- Installation and dismantling of heating networks
- Number and installed storage capacity for heat storage
- Number of installations and installed electrical and thermal power for district heating production

The Federal Statistical Office’s publications are based on data reported by the companies concerned. This data is confidential at company level and will not be published. It is only when the aggregation and case number of individual installations can no longer be applied to individual enterprises that the data are published. For example, aggregated data are available at federal level and more detailed data are made available on request for evaluation purposes. Additional information can also be consulted with a research assignment (see section**Error! Reference source not found.**).

The data from the AGEE-Stat[1] are published annually and sometimes supplement the data from the Federal Statistical Office. The BMWK energy data[2] are also public and updated several times a year and represent a summary of the available public statistics.

4.3 Energy Efficiency Association for Heating, Cooling and CHP (AGFW)

The AGFW's annual main report, which will be published as of the 2022 edition with a revised methodology and new content, will contain a number of data for the overall market for district heating production (as opposed to previous editions where only data from the member companies that participated in the large annual survey have been used).

The currently low output and quantities of heat from renewable energy sources and waste heat mean that the data may only be made available on an aggregated basis by the Federal Statistical Office (case number, or dominance criterion, see Section 3.5). With increasing shares of the individual categories, it is expected that in the future more heat production methods may be published without aggregation, which can then be presented in a differentiated manner in the AGFW main report.

The new edition of the main EBFW report will also publish an average primary energy factor (PEF) and an average CO_2factor. These factors are calculated by the Bremen Statistical Office, taking into account all fuels, quantities of heat and the amounts of electricity co-generated in CHP processes (including all subsets that cannot be published). For the calculation of the fuel needs of the heat from CHP processes, this is done using the "electricity credit method" as this method allows the factors to be calculated in sum for all similar processes (e.g. not taking into account temperature levels that are not collected by the statistics).

4.4 Other possible data sources

For reasons of confidentiality (dominance and case number), many energy statistics can only be provided by statistical offices in aggregated form. More detailed data may also be released for requests from research projects (with appropriate confidentiality agreements). It will be examined whether the legal situation can be changed in such a way that the data available in the statistical offices can be made available to a wider range of interested parties in order to be able to use it in the context of evaluations of funding programmes. In order to be able to access all energy statistics data under the current conditions, it might be possible to define the evaluation as a research project.

However, the statistical offices of the Länder do not have any data at the heat network level either. The establishment of a nationwide heat network charter, with the obligation for all heat network operators to update all parameters annually, would extend the data base for evaluating the BEW. In

[1] https://www.erneuerbare-energien.de/EE/Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/erneuerbare_energien_in_zahlen.html

[2] https://www.bmwk.de/Redaktion/DE/Artikel/Energie/energiedaten-gesamtausgabe.html

addition to technical data on networks and heat generators, this could also include information on the use of support programmes at federal, regional and municipal level.

5 Timing of the evaluation

The Directive already provides for regular monitoring:

- *¼-yearly monitoring of support for biomass installations. The share of biomass in the annual production of 25 % is not to be exceeded in the third year following the entry into force of the Directive.*
- *Annual monitoring of operating support*
- *As part of an in-depth evaluation, the support programme will be revised and adapted to current needs at the latest shortly before the expiry date of 2026/27.*
- *Duration: Period of validity of six years*

In addition to the aforementioned ¼ annual and annual monitoring, the following timetable will be proposed:

- **Interim evaluation report** after three years (adoption: Entry into force of BEW August 2022 => CA in August 2025).
    - Information on the state of play of funding on answers to evaluation questions based on annual data availability
    - Determination of the share of biomass in the third year after the entry into force of the Directive
- **Overall evaluation** half a year before expiry (adoption: Entry into force of BEW August 2022 => CA in December 2027)
    - Information on the state of play of funding on answers to evaluation questions
    - In particular, discussion of the questions on the continuation of the BUE as set out in section 8.5

6 Methodology for measuring the impact of the BUE

The evaluation of the BEW is based in principle on the idea of theory-based evaluation, which is based on the reconstruction and plausibility check of the operations. The chain of effects is 2 presented in section. It lists the products (outputs), results (outcomes) and effects (impacts) for which the relevant indicators have been identified in the evaluation questions. Theory-based evaluation is generally open to different issues and the use of both qualitative and quantitative methods, thus allowing different evaluation criteria to be considered. Reconstructing impact models provides indications of possible risks and challenges in achieving desired effects and in the emergence of possible unexpected side effects.

Counterfactual methods will ideally be used to measure the direct and indirect effects of the GUE in order to identify the causal effects of the support (see also SWD (2014) 179). The evaluation of the BEW should therefore, where possible, be supplemented by such counterfactual*impact evaluation* (CIE) in order to quantify the causality of BEW support to the outcomes under consideration. These are based on regression analyses of empirical data and in principle compare a *treatment*group of supported traits with a control group of unfunded traits. This control group should be as close as possible *to*the treatment group.

The basic possibility and depth of the use of causal methods depends crucially on the availability of data. This applies in particular to the control group of unsupported characteristics. While it can be assumed that the BEW will lead*to*a sufficiently large number of networks, the number of installations and networks operating without support is not yet foreseeable. Moreover, because microdata are used for causal analysis, their application depends on a sufficiently deep and broad data base at network level.

The following first sets out the general methodology on how to determine causal effects of BEW support. It then explains how the methodology can be applied to individual evaluation questions. This concerns in particular the identification of an appropriate control group.

6.1 Causal effect of BEW support for new installations

6.1.1 General approach

The causal effect is the difference between the result with and without aid from the BEW. To this end, the result *in*a treatment group which received support under the BEW is compared with the result in a control group which did not receive support under the BEW. The difference in result may be regarded as a causal effect if it can be reasonably assumed that the two groups are not systematically different, apart from the fact that they have received support or not.

Ideally, there will be a controlled experiment in which funding is randomly distributed among the key players, such as district heating networks. With a sufficient number of observations, no systematic differences can be expected due to the randomness of the group allocation. Statistical inference is carried out using a regression calculation:

$$Y = \beta_0 + \beta_1 X + \beta_2 C + U$$

Where *Y* is a dependent variable that captures the vector of *outcomes* of interest, such as the installed capacity of renewable heat generators, through all observed characteristics, such as heat networks. *X* captures, as an independent variable, the *vector* of treatment, such as the amount of support received by each characteristic carrier. It may also be coded in binary as a *dummy* if the amount of *treatment* or support is not examined, but rather whether or not *a* characteristic has received treatment or support. Observations that do not receive treatment are in principle in the control group. The parameter β_1 measures the influence of *Treatment X* on *Outcome Y* and is therefore of central interest in the evaluation. Vector *U* includes, as an error term, all unobserved influences on *Y.*

These unobserved influences should be randomly spread around zero and thus have no systematic influence on *the* outcome. In particular, a correlation between the unobserved term *U and*the treatment variable of interest *X* would result in *X*'s influence on *Y* measured by being $\beta_1$systematically distorted by unobserved characteristics of the characteristic carriers. In this case, there is a *bias* due to endogenicity. This is less relevant in experimental setting because the random allocation of treatment makes such systematic unobserved influences very unlikely. On the other hand, the vector of control variable *C* is included in an evaluation using empirical data. This includes other observable characteristics of the characteristic carriers that may have an impact on the *outcome* — in the case of heat networks, for example, the length of the grid or the performance of different fossil heat generators. This addresses the issue of endogenity. This equation is filled with the observed data. Using the least squares method, the parametersβ_0,β_1, and β_2 the model shall be estimated.

Control *variable C* is a basic way of recording observable differences between *the*treatment and control characterisation agents. They exclude observed differences from the influence of *treatment* and make the two groups more statistically comparable. Nevertheless, systematic differences may persist. These are ideally addressed in a counterfactual evaluation design. In principle, the referring court asks how the *outcome* would have developed in *the*treatment group if no treatment, that *is* to say, no support, had taken place. This counterfactual case is not observable by design. Therefore, the Treatment Group is compared with a control group as close as possible to the treatment group, which can be assumed to *have*developed as the treatment group had it *not* received. For this purpose, several methods are possible, such as*regression discontinuity analysis (RAA*) and *propensity score matching.* In addition, differences between characteristic carriers can be excluded from statistical inference through the use of panel data.

The applicability of the methods presented here in principle depends on the specific evaluation question and the availability of data. A detailed description of evaluation question 1.2 is provided below. For the other questions, the approaches described therein can be applied by analogy and only relevant differences with the methodology for question 1.2 are addressed.

- Question 1.1: Causal effect of BEW support on the share of renewable energy in heating networks
- Question 1.2: Causal effect of BEW support on the output of renewable heat generators
- Question 1.9: Causal effect of BEW support on the combination of RES heat technologies in heating networks
- Question 1.10: Causal effect of BEW support on the number, length and temperature level of heat networks
- Question 2.1: Causal effect of BEW support on the share of losses in heat networks
- Question 2.3: Causal effect of BEW support on the primary energy factor in heat networks
- Question 2.4: Causal effect of BEW support on the $CO_{2\ \text{emission factor}}$in heat networks

- Question 2.9: Causal effect of BEW support on the competitive situation in heating networks

6.1.2 Impact of BEW support on renewable heat production (evaluation question 1.2)

In order to analyse the effect of BEW support on RES heat production output, descriptive statistics are first produced. At the level aggregated across all grids, these compare the timing of the support with the timing of renewable heat production in a tabular and graphical way. From this, a first trend can be derived as to whether an increase in support correlates with an increase in *outcomes*. Descriptive statistics of interest, which capture the support, include, for example, the funding cases, the amounts paid (investment support, operating support) or the average amount per funding case. Descriptive statistics of interest that capture renewable heat output include, for example, absolute output, average renewable or waste heat output per aid case, or the ratio of supported investment and operating costs.

Data at the level of the heat networks will be used for the more detailed causal analysis. A heat grid register is ideally used for this purpose. This represents, for each network, or a large number of networks, at least the output of generation technologies, the quantities of heat produced each year and the subsidies paid from the BEW or other sources. These are the key variables in the sense of causal analysis. Other characteristics of interest are the length of the network or any other indication of its size, the temperature level, the size of the heat reservoirs available, as well as information on the number and structure of the points of purchase and heat prices (performance and labour prices). The wider (network coverage) and deeper (information available, completeness of information) the more robust the data base, the more robust it is possible to produce descriptive statistics or carry out final studies.

It is also checked whether new construction networks have been built during the evaluation period which did not benefit from BEW support. If this is not the case, it can be assumed that these networks would not have been built in the absence of BEW support and that the BEW support can be considered to be the cause of the construction of the new heat network and the addition of renewable heat generation installations in the new networks. The empirical analysis in this case only covers stock networks. If new construction networks are also built without support from the BEW, new construction networks can also be included in the empirical study.

Where sufficiently deep and wide data are available at the level of the heat networks as a characteristic carrier, the output of renewable heat generator and waste heat present in each heat network in one year shall be used as an *outcome* of interest (variable to be explained). The *Treatment*Group is defined in the simplest case by all networks in which investment support by the BEW (systemic support, individual measures) has taken place over a specified period. The period of time must be such that there is sufficient time for implementation between the approval of the funding and the commissioning of the installations. The basic control group consists of all networks in which no support from the BEW has taken place.

For interpretation as a causal effect, the allocation of installations to treatment and control groups shall not systematically correlate with unobserved factors in the error term of the model (endogenous regressor). Furthermore, the realisation of renewable heat generation installations must not affect the application for aid under the BEW (reverse causality) if, for example, installations which have already been developed without support apply for support. Both cannot be directly tested. The first point (endogenous regressors) is answered by appropriate control variables. These are used to systematically record further influences on the construction of renewable heat generation installations, so that they are not wrongly attributed to the central explanatory variable, BEW support. The second point (reverse causality) can be narrowed down by the analysis of the profitability gap to be presented by stakeholders. In any case, the result would at least be a correlation that suggests causality with existing sector knowledge.

The control variables may include the length of the network, the number of points of purchase and the number of large customers, as well as variables that capture the share or performance of different fossil heat technologies in the networks and corresponding fuel and certificate prices affecting the variable costs of heat production. These control variables anticipate the influence of these factors on the effect of production. Their inclusion in the regression equation makes *treatment*and control groups more comparable statistically. The estimate shall be made in accordance with the regression calculation 6.1.1 described in Chapter. The result is the effect of support in a grid, at whatever level, on the average additional production of RES heat generators.

With a sufficient number of observations, the results may be subjected to robust statistical sensitivities tests. Statistical significance means that the identified difference between subsidised and unsubsidised networks is not due to chance with a reasonable probability.

The basic control group consists of all networks that have not received any BEW support. Relevant complementary information is whether support has been provided in a network from another source, e.g. through programmes at Land level. Such networks are either excluded from the analysis or identified with a corresponding variable. Where no renewable heat or waste heat has been built up in unsubsidised networks, the effect of the BEW support is the total addition of the networks in which aid for RES has taken place, corrected for the influence of the control variables. If renewable heat or waste heat is also built up in networks without support, the effect is due to the differences in additional construction, adjusted if necessary by the control variables in the regression.

Ideally, the control group can be narrowed down to networks similar to those supported but where no support has taken place. This is called the identification strategy. In principle, depending on the available data, the challenge is that the control group may include only a small number of networks. A further reduction of the population in the analysis would both reduce the robustness of the closing statistics and make the study vulnerable to outliers in the data. The applicability and robustness of the following identification strategies therefore depends on the data situation and can be checked once the data is available.

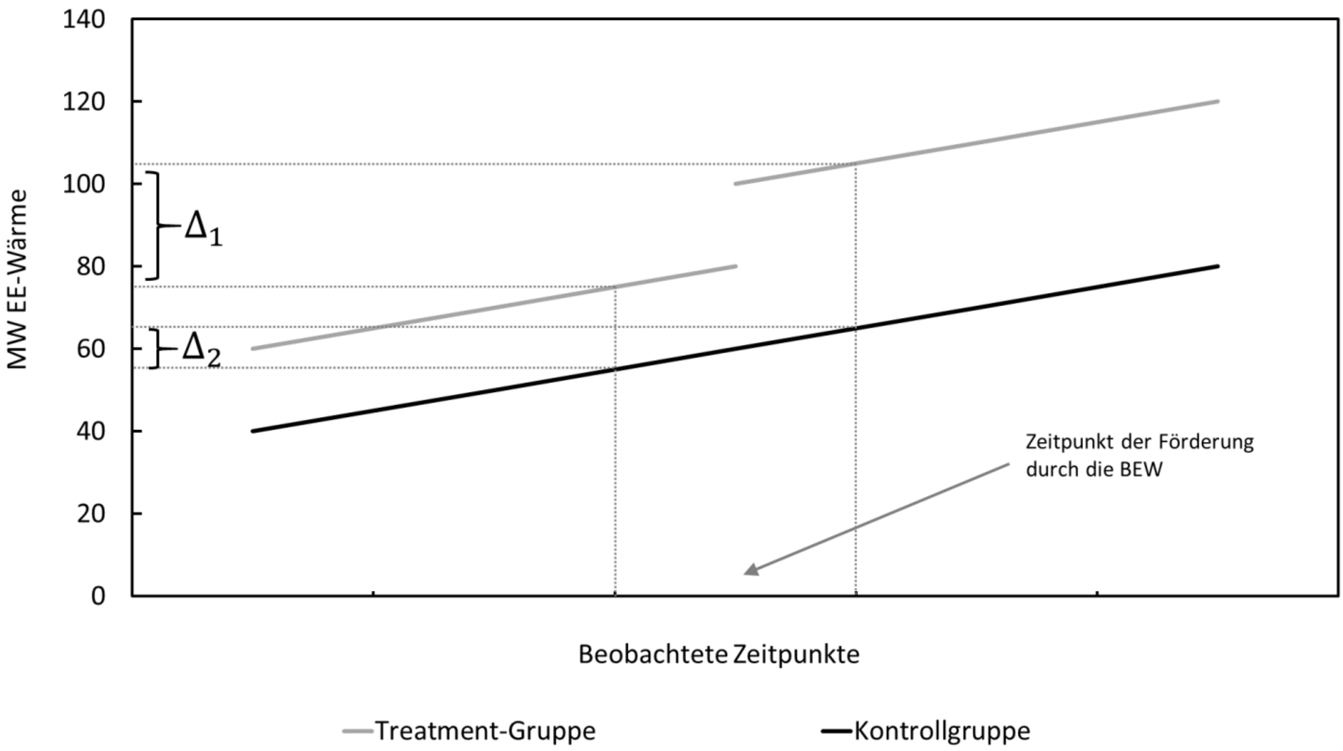
- A fundamental identification strategy is the*regression discontinuity analysis (* RAA). For this purpose, networks are used as a control group which resemble the subsidised networks in relevant characteristics (continuity), but are not supported because of a reason which is as uncorrelated as possible with both these relevant characteristics and the *outcome* (discontinuity point). If, for example, the funding was awarded in a competitive manner, the discontinuity point could be set between the networks that are still successful in competition for funding and the networks which are just so unsuccessful. In this case, it could be plausible to argue that the structure in these networks, for example in terms of costs, is sufficiently similar to ensure good comparability. However, there is no competition *per se* for scarce funding; this discontinuity point is in principle null and void. However, if the data and acceptance of support are sufficiently broad, it can be exploited if applications for support cannot be granted because the funding budget in the BEW has been exhausted. In this case, networks in which actors have wanted but not received funding would be compared with networks that have sought and received funding.

- On the basis of the data available, a stratification can also be carried out. This means that networks are divided into groups (rate) according to one (or more) key features. These characteristics are, for example, the size of the network (line length) and/or the share of fossil heat from coal or natural gas. A treatment and a control group *are*formed within each stratum. While stratification is not an identification strategy in the sense of counterfactual analysis, the comparability of groups can be improved by appropriate stratification.

- On the basis of the data available, a *propensity score matching approach*can also be examined. This follows a similar logic to stratification. It aims to select a control group as a subset of all non-assisted networks, which is as close as possible to the treatment group in terms of *several*key characteristics. If the treatment group is *characterised*, for example, by particularly large networks and, in particular, by networks with a few larger customers, the same control group may be selected on the basis of the *propensity score*. The *propensity score* is a statistical metric used to select, on the basis of observable characteristics, a subset that *is*as close as possible to the treatment group from all unsupported networks. If, on *the*other hand, the treatment group is very heterogeneous, it is more difficult to choose a plausibly comparable control group. In this case, the *propensity score* may be prone to random influences and therefore not robust.

- Furthermore, a *difference-in-difference (DID) design*based on panel data can be examined. Panel data is available when the same observations, i.e. networks, are observed over several times. In this case, properties for which data are not available may be statistically calculated from the model to be*estimated and*the estimation of the effect of treatment is not distorted by unobserved, time-constant influences. The effect of the support is calculated as the difference between two differences$\Delta_1 - \Delta_2$, seeFigure1. The difference in Δ_1 the *outcome of* all supported networks, i.e. the installed RES heat output, is before and after the date of support. $\Delta_2$is the difference in the *outcome* of all unfunded networks before and after the date of funding. The difference between the differences can be interpreted as a causal effect of the support if it can be reasonably assumed that *the*treatment group of the subsidised networks would have developed in the same way as the unsubsidised networks without any support. This central assumption is referred to as *parallel trends*. It is assumed that the development in the control group can be *regarded*as a counterfactual development of the treatment group if no treatment had *taken* place there. This assumption cannot be tested. However, it must be possible to argue that it is plausible. In the DID analysis, the basic control group is also the group of all unfunded networks. In order to better identify the model, a *propensity score matching approach*or a regression discontinuity analysis can also be tested here.

Figure1: Schematic representation of a *difference in difference*analysis



A refinement of the analysis is to define the independent variable *X* as the sum of the (investment) support paid in a network, rather than a binary *dummy*variable that any support at all has taken place. This makes it possible to determine the effect of the level of financial support on the construction. To this end, data on the amounts of support (investment support) must be available. It is possible, in principle, to consider operating grants in a differentiated manner.

Overall, it should be noted that data availability is a critical factor in the proposed causal analysis. The number of networks either receiving funding or not is limited at the expected implementation horizons. This applies in particular to the RDA, which only considers networks above and below the minimum size for support. In addition, data at network level still needs to be collected in an appropriate form.

In the absence of sufficient data at network level, the characteristics of undertakings may be used as an alternative. However, there would be no relevant control variables that have a plausible impact on renewable heat production in networks (with and without support), such as the structure of existing heat production and its costs.

In the absence of sufficient data at enterprise level, descriptive statistics at aggregated level may be combined with an in-depth analysis of the profitability gap calculations, which must be submitted by enterprises as a counterfactual basis for support under the BEW. Depending on the use of these calculations, relevant insights can be obtained on the economic viability of renewable heat production compared to other sources and on the extent to which the support helps to establish comparable conditions. In particular, it can be examined whether and for what reasons measures or bundles with a negative profitability gap have nevertheless been implemented. However, due to self-selection and possibly common specificities, these do not constitute a control group in the sense of counterfactual causality analysis. This view can be complemented by interviews with selected stakeholders in order to identify causal factors qualitatively.

6.1.3 Analysis of other causal issues

In principle, the same approach as for evaluation question 1.1 is taken for the other questions.

- Production of descriptive statistics, examination of any funding available outside the GEA;
- Causal analysis at the heat network level with the construction of a counterfactual control group by testing RDA, stratification, *propensity score matching* and DID approach, provided that the relevant data are sufficiently wide and deep available;
- in the alternative, analysis of the present profitability gap calculations, supplemented, where necessary, by qualitative studies and interviews.

All applications of the proposed causal methods are subject to a sufficiently broad and deep availability of data.

Effect of BEW support on the share of renewable energy in heating networks (evaluation question 1.1)

The *output* of interest (dependent variable) is the share of RES heat in each grid. In addition, in the implementation, a weighting according to the size of the networks is applied. Alternatively, in order to take account of potential growth in grid demand, the renewable heat produced in absolute terms per grid may be used as a dependent variable, provided that such data are available.

Impact of BEW support on the combination of RES heat technologies in heating networks (evaluation question 1.9)

The *output* of interest (dependent variable) is the number of RES heat technologies in networks.

Effect of BEW support on the number, length and temperature level of heat networks (evaluation question 1.10)

The *outputs* of interest (dependent variables) are the length and temperature level of the networks. If new networks are also set up without support from the BEW, this issue can also be examined empirically. Otherwise, it is plausible to assume that the BEW support has been the cause of the construction of new networks, or its share cannot reasonably be examined in a counterfactual design.

Effect of BEW support on the share of losses in heat networks (evaluation question 2.1)

The *output* of interest (dependent variable) is the share of losses in the heat networks. Alternatively, in order to select a variable depending on the size of the grid, the absolute heat loss per grid may be investigated, provided that appropriate data are available or can be constructed.

Impact of BEW support on the primary energy factor in heat networks (evaluation question 2.3)

The *output* of interest (dependent variable) is the primary energy factor in heat networks. In order to analyse an effect on the ratio of total primary energy input to total final energy, each network may be weighted by a variable measuring its size in the analysis. In any case, the effect of CHP heat production and the method of primary energy allocation to heat and electricity must also be accurately captured (see section6.2.3).

Effect of BEW support on the $CO_{2\ \mathrm{emission\ factor}}$in heat networks (evaluation question 2.4)

The *output* of interest (dependent variable) is the $CO_{2\ \mathrm{emission\ factor}}$in heat networks. In order to analyse an effect on the ratio of total emitted CO_2 to total final energy, each network may be weighted by a variable measuring its size in the analysis. In any case, the effect of CHP heat production and the method of primary energy allocation to heat and electricity must also be accurately captured (see section6.2.3).

Effect of BEW support on the competitive situation in heating networks (evaluation question 2.9)

The *outcome* of interest (dependent variable) is a measure of competitive intensity in heating networks. This may be represented by the Herfindahl-Hirschmann index (*HHI*) or the *CR* concentration rates in a network. Depending on the data available, the relevant market shares may be based on the installed heat production capacity or the heat supplied.

6.1.4 Top down modelling

*Bottom-up*analyses on the effectiveness of RES can be supported by modelling projects that allow for *top-down*results. The impact of BEW in terms of district heating production or total heat production could be shown. At present, the focus would be on **ex-ante effects**, as the measurability of the **ex-post effects** of the BEW is expected with a time lag: These effects occur with a long time lag in general statistics and then have to be processed in modelling processes that also take time. A time lag from the initial effect to ex-post observation in a modelling of up to three years is expected.

6.2 Methodological approach for further selected evaluation questions

6.2.1 Analysis of the share of losses for district heating production

The loss share is defined as heat production minus heat consumption divided by heat production. One possible data source for this is the items ‘Conversion emissions’ and ‘Total consumption’ from Table 25 ‘Resources and use of district heating’ of the BMWi Energy Data.

6.2.2 Study of the energy mix for district heating

The energy mix for district heating production can, for example, be directly taken from Table 25 'Resources and use of district heating' of the BMWi energy data in the form of absolute values or verified by means of a separate compilation of data from the Federal Statistical Office, supplemented, where necessary, by other sources. In addition, this information may also be reported as relative shares. In this case, the indicator also includes the development of overall district heating production, for example due to temperature variations (aged or warm winter) or the combination of efficiency gains from building renovation on the one hand and increasing compaction and new construction of heat networks on the other.

6.2.3 Analysis of the specific $CO_{2\ emission}$factor and the primary energy factor (PEF) for district heating production

The procedure for determining the specific $CO_{2\ emission}$factor for district heating is based on the procedure for determining the specific $CO_{2\ emission}$factor for the German electricity mix[3]. The specific CO_2emission factor is an indicator of the climate compatibility of district heating production and is reported in the unit 'g_{CO} 2/kWh heat'. The numerator of this indicator is the CO_2emissions caused by the use of fossil fuels.

As CHP plays an important role in heat generation for district heating systems, the assessment method of heat from CHP installations has a major impact on both factors. There are different methods (e.g. electricity credit method, carnot method, Finnish method) for splitting the fuel input between the heat and electricity CHP products, with very different results.

For example, the $CO2_{factor}$ of CHP heat, calculated using the Finnish method, is significantly higher than the CO_2factor of the same CHP plant calculated using the Carnot method. On the other hand, the CO_2 factor of the electricity produced at the same time is calculated using the Finnish method significantly less than if it is calculated using the Carnot method. In order to compile the 'energy data' of the BMWK, the CHP fuel is likely to be split up using the so-called 'Finnish method', whereas the EBFW uses the 'electricity credit method'. For an overview of the different methods, see e.g. BDEW 2015[4].

For this reason, the method selection must be carried out with care and the method chosen must be applied consistently in order to ensure comparability between different technologies and time periods. It is therefore recommended to carry out the calculation of the primary energy factor or CO_2emission factors as part of the evaluation following a discussion of methods based on the basic data.

[3] https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-05-26_cc-45-2021_strommix_2021_0.pdf
[4] https://www.bdew.de/media/documents/20150422_Grundlagenpapier-Primaerenergiefaktoren.pdf