1 Method description for the cost-benefit analysis

1.1 Comparison of technologies

The socio-economic present value heat price of each type of generation facility is estimated for technical-economic comparison. The most important elements of the socio-economic present value heat price are explained below.

- The present value price of the capital contribution is estimated by converting the investment per MW for the investment per MWh when choosing the expected typical service life of the facility (technology). It is assumed the investment will be made in 2020. For district heating systems, it is assumed that the priority base load has a service life of around 8 000 hours/year, while flexible base loads and intermediate loads have a service life of 4-5 000 hours/year.
- The present value price of the operating contribution is the socio-economic present value heating price of each generating facility in DKK/MWh, including costs for energy, environment, operation and maintenance, but excluding capital costs.
- Emissions expenses for greenhouse gases are recognised on the basis of the CO_2 price forecast in the Danish Energy Agency’s price assumptions. Fossil energy facilities (excluding waste incineration) with an input of at least 20 MW are subject to quotas in EU ETS. It is generally assumed in calculations that all fossil district heating facilities (excluding waste incineration) follow the assumed CO_2 price forecast.
- Cost of damage for the emission of local pollutants: SO_2/SO_4, NO_x and $PM_{2.5}$ are included because district heating is assumed to follow SNAP 1 and individual facilities SNAP 2; see Table 15 of the Danish Energy Agency's price assumptions. Biomass fuels are additionally subject to an unpriced risk that handling and storage may lead to contamination of the environment with biological agents (moulds and bacteria, etc.).
- Tax distortion losses from costs are expected, but tax distortions arising from State aid schemes for renewable energy are disregarded.

Base load technologies for example include waste cogeneration or cogeneration, while medium load technologies typically include cogeneration facilities and large heat pumps for district heating. District heating facilities fired with natural gas or oil may be used as intermediate load facilities, but will most often only be used as peak load and reserve facilities, resulting in a significantly lower service life and thus much higher capital costs in the case of a new facility.

1.2 Mechanisms in the socio-economic cost-benefit analysis

The solution with the lowest present value cost over the technical service life is generally considered to be the best socio-economic solution. For a district heating system with several different facilities, the combination of facilities (technologies) with priority operation will create the final present value heat price. If the technology has already been invested in before 2020, the capital contribution (sunk cost principle) will lapse or be reduced to contributions from later renovations.

In order for district heating technology solutions to be compared with the corresponding present value costs in DKK/MWh for individual facilities, i.e., to the customer, the cost of heat distribution (including customer systems) has been added, where three alternative customer connections have been set up:

1. Central new customer, i.e. where a new customer is connected to a branch line in the district heating area.
2. Marginally ideal new customer, i.e., where a new customer is connected using a street and branch line in a peripheral area to the district heating, but where there is 100% customer connection in the area.
3. Marginal new customer, i.e., where a new customer is connected using a street and branch line in a peripheral area to the district heating, but where a transmission line is required and where there is only 75% customer connection.

For a marginal district heating customer (alternatives 2 and 3 above), the most expensive generation facilities in the district heating system in question will be responsible for covering the marginal heating demand. Thus, if the marginal generation mix costs DKK 410/MWh, and the cost of heat distribution is DKK 212/MWh, the total cost of covering the customer's heating needs using district heating will be DKK 622/MWh. In comparison, a heat pump solution will cost DKK 614/MWh and would therefore be more socio-economically attractive in this example.

The comparison generally assumes a heating consumer with a net heat demand of 16.7 MWh/year (single-family house), which is the weighted net heating demand that is assumed to decrease due to general heat savings from an average of 18 MWh/year in 2020 to 15 MWh/year during the analysis period.

1.3 Comparison of development alternatives during the period 2021–2050

An analysis is performed for specific district heating solutions in calculation group 2. In addition, 10 types of district heating systems have been set up – divided into large, medium-sized and small towns. The six largest district heating systems in Denmark are named after the cities in question. These are therefore the dominant heat supply in the city in question and cover a well-defined district heating area in the city according to the zoning of the heat supply in urban buildings, which is required by the Danish Heat Supply Act. The district heating systems in the medium-sized and small cities are considered in the analyses as type systems without a specific geographical indication.

The analysis covers the period 2021-2050, i.e. 30 years. However the Danish Energy Agency's guidelines[1] calculate the socio-economic costs over a time horizon of 20 years, which is why the Danish Energy Agency's forecast only goes up to 2040. Constant fuel prices are assumed from 2040 to 2050 in order to calculate a 30-year time horizon.

A combination of specific existing district heating generation facilities based on the Danish Energy Agency's Energy Producer Count from 2018 has generally been established for each of the 10 district heating systems. When existing facilities are decommissioned, or are converted to green heat before the end of the service life of the facility, it is assumed that investments can be made throughout the calculation period (2021-2050), which may lead to correction for scrap values in the end year 2050, i.e. if facilities have a remaining service life in the year 2050.

Heating consumers may either be located inside or outside a district heating area. These are designated:

1. Central: The consumer is located in an area currently designated for district heating. Continued use of district heating in one of the 10 district heating systems may be compared with conversion to an individual heating supply.
2. Marginally: The consumer is located in an area designated for natural gas, but is either converted to district heating in connection with the expansion of one of the 10 district heating

[1] https://ens.dk/sites/ens.dk/files/Analyser/samfundsoekonomiske_beregningsforudsaetninger_for_energipriser_og_emissioner_2019.pdf

systems or to an individual heating supply where the socio-economically most attractive solution is generally air to water heat pumps.