Energistyrelsen

1 Method description for the determination of surplus heat

The business sector's surplus heat potential in Denmark is estimated by combining two methods – a top-down and a bottom-up method. Using both methods improves the accuracy of the analysis.

The first method is based on Statistics Denmark's (DTS) database *ENE2HA*[1]*:* Energy accounts in GJ according to use and energy type (*Energiregnskab i GJ efter anvendelse og energitype*), Danish Building and Housing Register (Bygnings- og Boligregistret, BBR), the Danish Address Register, the Joint Municipal Property Register (Ejendomsstamregister, ESR) and the Central Business Register (CVR). Surplus heating sources with an estimated generation capacity of less than 20 MW are eliminated. However, the method is associated with a certain element of uncertainty, including because it is largely based on assumptions and estimates. The mapping of surplus heat is based on the following steps:

1. The ENE2HA database from DST is used to find the annual energy consumption divided according to energy type and application (industry code DB07). Energy volumes from the most recent energy accounts (2017) are divided into production processes (e.g., drying and evaporation), where the distribution key appears in the report 'Assessment of energy consumption by businesses'.[2] Typical efficiencies are used for industrial processes to assess the amount of surplus heat available. The result is the total amount of surplus heat from thermal processes for each industry.
2. The total amount of surplus heat in each industry is divided among individual production units in Denmark. The area of the buildings used for generation purposes is used as the distribution key. The generation units in each industry are determined via CVR. The location address of the production unit is determined via the Danish Address Register DAF. BBR and ESR are used to identify the commercial area of the individual production units. The result is a list of production units for each industry with associated commercial area.
3. Based on the total commercial area in each industry and the total amount of surplus heat/energy consumption, a distribution key (GJ/m^2) is calculated which is multiplied by the commercial area of the individual production units.
4. In order to introduce a threshold of 20 MW thermal input on surplus heat sources, energy consumption for the individual production units is divided by an assumed number of full load hours of 2 000 hours. Generation units with a thermal input of less than 20 MW are excluded from the surplus heat list, as EED contains no requirement to assess surplus heat sources less than 20 MW.

The method is based on a top-down approach and contains several sources of uncertainty. The distribution of energy consumption by industry, process efficiency and full load hours is based on key figures, empirical data and assumptions. In addition, some data sets are incomplete (e.g., CVR), and there are some inconsistencies in the links between the data sets (e.g., CVR and BBR). Finally, there is some uncertainty in the method itself where commercial area is used for

[1] https://www.statbank.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENE2HA&PLanguage=0

distribution. However, the uncertainty is expected to be relatively low because the distribution key is based on industries containing the same type of industrial enterprises.

The second method is based on the registration of CO_{2e} emissions reported by large enterprises in Europe as part of the EU Emissions Trading System (EUETS). Only enterprises with a thermal input of more than 20 MW are covered by EUETS, which applies to this potential assessment. Additionally, the combination of different databases helps to ensure as many enterprises as possible are included in the assessment. The EUETS list for 2018 in Denmark requires that each enterprise name has an industry code and production location address. The CO_{2e} emissions reported are converted to energy consumption by multiplying the CO_{2e} intensity of the fuel consumed. The fuel is then multiplied by an overall thermal efficiency for the enterprise/facility. Values for the CO_{2e} intensity and thermal efficiency used are from the following source[3] and can be found for the overall industries shown in Table 1.

Sector activity	**Thermal efficiency [%]**	**CO_2 factor [g CO_2/MJ]**
Fuel and refineries	25	73.3
Chemical and petrochemical	25	58.7
Iron and steel	25	58
Non-ferrous metal	25	56.1
Non-metallic minerals	25	75.3
Paper and copy paper	25	82
Food and drinks	10	65.1
Pharmaceutical and medical	10	65.1
Mechanical	25	56.1

Table 1 Thermal efficiency and CO_{2e} intensity (source: Rambøll).

Two further categories have been added of particular relevance for Denmark; these are 'Pharmaceutical and medical' and 'Mechanical'. The two categories have been added because they do not appear in the account[14], but are considered to be a significant source of surplus heat. The category '*Pharmaceutical and medical*' covers the manufacture of medicines. The category '*Mechanical*' covers industries manufacturing pumps, valves, compressors and generators, etc. The thermal efficiency has been adjusted for refineries from 50% to 25% to better represent existing conditions in Denmark. This is done to avoid overestimating the potential to utilise surplus heat from refineries, which accounts for a large amount of the surplus heat in Denmark.

An exception to the method is the manufacture of cement, where large quantities of CO_2 are generated in addition to the actual combustion of fuel. The exception is based on a bottom-up approach, where information provided to Rambøll from companies themselves in other contexts is used to estimate surplus heat.

The bottom-up and top-down method are combined. This reduces the risk of a large surplus heat source being overlooked and not included. Data from EUETS is used first. The list from EUETS is compared with the list obtained from the CVR analysis. Enterprises are added that appear in the CVR analysis but are not in the EUETS list, but which are expected to have a surplus heat potential.

[3] U. Persson, B. Möller, and S. Werner, "Heat Roadmap Europe: Identifying strategic heat synergy regions," Energy Policy, vol. 74, no. C, pp. 663–681, 2014.

1.1 Distance to the district heating network

The amount of surplus heat that can be utilised depends on whether there is a possible heat sink. In order to utilise a large amount of surplus heat (output of 20 MW or more), there must be access to a district heating network supplying a city with a significant heating demand. The distance between the surplus heat source and the district heating network must be relatively limited to avoid investments that are too large in relation to the amount of heat. The surplus heat company may also purchase a certain amount of heat itself.

In the analyses, Rambøll takes into account distance to the district heating network. Rambøll enters the surplus heat sources into GIS with a buffer corresponding to the maximum distance for the heat transmission to be profitable. It is assumed that a surplus heat source may be utilised profitably if the buffer zone overlaps with a nearby existing district heating area. Heating demand in a given area has not been taken into account, and the potential identified must therefore be considered as a screening and a theoretical potential. The distance is calculated via investment costs per metre of pipe and a defined percentage that investment in district heating pipes may constitute in the total heating price. Figure 1 illustrates the maximum length of pipelines as a function of surplus heat quantity where it is profitable to connect the source to the district heating network.

EUR 15, 25 and 35/GJ have been used for each surplus heat source identified to illustrate how far a given source of surplus heat can reach at different heating prices. The buffer that is profitable depends on the factors described above, and also on the substitution price for heat in the local area, which varies nationally.

Table 2 indicates the price calculated per metre of pipeline using different pipe dimensions. The distance that surplus heat can be transported depends on the amount of surplus heat available. The distance that the surplus heat can be transported is indicated by the three different price ranges.

Pipe dimension	Price per metre of pipeline	Derived heat	EUR 15/GJ	EUR 25/GJ	EUR 35/GJ
-	[EUR/m]	[TJ/year]	[m]	[m]	[m]
DN15	211	0.1	4	7	10
DN20	227	0.1	8	14	19
DN25	243	0.2	15	24	34
DN32	250	0.5	28	46	65
DN40	259	1	39	66	92
DN50	284	1	67	112	157
DN65	482	3	78	130	182
DN80	536	4	107	178	249
DN100	608	8	189	315	441
DN125	734	13	273	456	638
DN150	743	22	447	745	1 043
DN200	1 014	45	663	1 106	1 548
DN250	1 351	81	898	1 496	2 094
DN300	1 654	127	1 155	1 925	2 695
DN350	1 865	164	1 319	2 199	3 078
DN400	2 102	233	1 663	2 772	3 881
DN450	2 432	319	1 969	3 281	4 594
DN500	2 742	425	2 323	3 872	5 421
DN600	3 308	688	3 118	5 197	7 276
DN700	3 730	1 022	4 110	6 850	9 590
DN800	4 204	1 462	5 215	8 692	12 169
DN900	4 865	1 870	5 767	9 611	13 456
DN1000	5 483	2 310	6 320	10 533	14 746

Table 2 Distance surplus heat source can be from district heating network at different price ranges (sources: Rambøll).

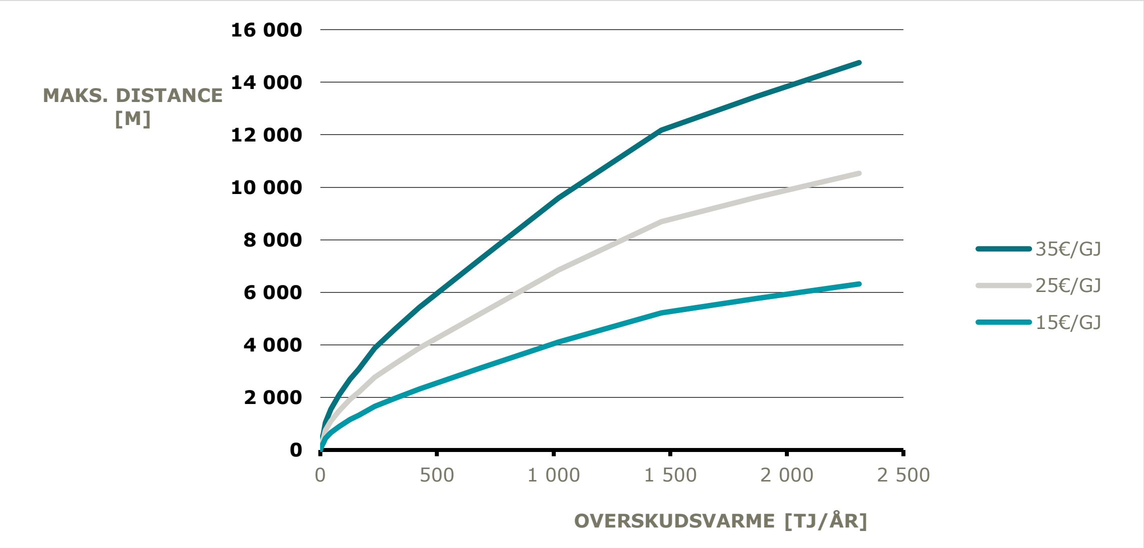

Figure 1 Maximum viable pipeline distance to connect the surplus heat source to the district heating network (source: Rambøll).

MAKS. DISTANCE [M]	MAX. DISTANCE [M]
OVERSKUDSVARME [TJ/ÅR]	SURPLUS HEAT [TJ/YEAR]
35€/GJ	EUR 35/GJ

Utilisation of surplus heat also depends on the temperature of the surplus heat. A heat pump is required to utilise the surplus heat if the temperature of the surplus heat is too low in relation to the temperature of the district heating network. The actual utilisation potential will therefore depend on many factors that may affect the economy of the project. The effect of the temperature set has not been taken into consideration in assessing surplus heat potential.