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Background report on evaluation of thresholds for exemptions under Article 14(6) of the Energy Efficiency Directive

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Kavvadias K.
Santamaria M.
Carlsson J.
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Joint Research Centre

EUR 28445 EN

Contact information
Name: J. Carlsson
Address: European Commission, Joint Research Centre, Westerduinweg 3, 1755 LE Petten, the Netherlands
Email: johan.carlsson@ec.europa.eu
Tel.: +31-224-565341

JRC Science Hub
https://ec.europa.eu/jrc

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Background report on evaluation of thresholds for exemptions under Article 14(6) of the Energy Efficiency Directive

Article 14 (6) of the Energy Efficiency Directive allows Member States to exempt certain installations from the requirements of conducting a cost-benefit analysis of individual installations as stated by Article 14 (5).
This report compares MS notifications on exemptions concerning laying down thresholds with general benchmark thresholds and with thresholds estimated through a general techno-economic model. Finally, this report provides recommendations how the exemptions thresholds ought to be defined, in order not to a priori exclude feasible heat linking options.

Contents

Foreword

This work was carried out in the framework of an Administrative Arrangement of DG ENER and JRC, in which JRC provided technical assistance, analysis and input to support the implementation of Article 14 of Directive 2012/27/EU on energy efficiency.

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Authors

Kavvadias, K

Santamaria, M

Carlsson, J

Executive summary

This work was carried out in the framework of an Administrative Arrangement of DG ENER and JRC, in which JRC provided technical assistance, analysis and input to support the implementation of Article 14 of Directive 2012/27/EU on energy efficiency.

This report compares MS notifications on exemptions concerning laying down thresholds with general benchmark thresholds and with thresholds estimated through a general techno-economic model. The report also provides recommendations how the exemptions thresholds ought to be defined, in order not to a priori exclude feasible heat linking options.

Policy context

Article 14 (6) of the Energy Efficiency Directive allows Member States exempting installations from the requirements of conducting a cost-benefit analysis of individual installations as stated by Article 14 (5). For instance, Member States may lay down thresholds, expressed in terms of the amount of available useful waste heat, the demand for heat or the distances between industrial installations and district heating networks, for exempting individual installations from the provisions of points (c) and (d) of paragraph Article 14(5).

Key conclusions

The review of Member States exemptions reveal that most thresholds were based on fixed values for distance, waste heat, as done by Poland, Demark and Austria, Netherlands. This approach does not consider that larger amount of available heat can be economically transferred longer distances. In some cases the thresholds were based on a relation between distance and available heat, as done by Slovenia, Greece, UK and Finland. This approach is more appropriate as it considers that higher available heat can be transferred to longer distance. However in this case a link to other parameters is missing (temperature, availability).

In most cases the distance thresholds are too conservative. They usually fall into the range of 5 – 20 km whereas literature current practices and preliminary analysis show that bigger distances can be economically viable. As a consequence, heat linking opportunities might be missed. The same can be observed for the peak heat: e.g. Germany indicates that an installation with less than 10 MW of waste heat should exempt from a CBA whereas a nearby located heat consumer could benefit from it.

1 Introduction

Article 14 (6) of the Energy Efficiency Directive allows Member States exempting installations from the requirements of conducting a cost-benefit analysis of individual installations as stated by Article 14 (5). These installations are:

1. Peak load and back-up electricity generating installations which are planned to operate under 1 500 operating hours per year as a rolling average over a period of five years, based on a verification procedure established by the Member States ensuring that this exemption criterion is met;
2. Nuclear power installations;
3. Installations that need to be located close to a geological storage site approved under Directive 2009/31/EC.

Member States may also lay down thresholds, expressed in terms of the amount of available useful waste heat, the demand for heat or the distances between industrial installations and district heating networks, for exempting individual installations from the provisions of points (c) and (d) of paragraph Article 14(5).

Member States had to notify exemptions adopted under this paragraph to the Commission by the end of 2013. The aim of this report is to provide a critical technical evaluation of those thresholds. Section 2 of this report provides a general overview of notifications reports and type of exemptions notified by MS. Section 3 of the report includes, firstly, a comparison with general benchmark thresholds and secondly, a general techno-economic model to estimate thresholds. Section 4 presents the conclusions of this report and provides recommendations on how the exemption thresholds ought to be defined.

2 Overview of MS notifications

This Section is intended to provide a general overview of MS notification reports. As can be seen in Table 1, nineteen MS opted to notify a report concerning exemptions to the European Commission by 31 December 2013. Regarding the requested exemptions based on the type of plant, the number of countries requesting it is:

- Fourteen MS exempted peak load/back-up electricity installations operating <1500 hours p. year;
- Twelve MS exempted nuclear installations;
- Eleven MS exempted installations located close to a geological storage site.

Table 1 MS exemptions notifications received by EC and exemptions requested

	Exemptions report sent	**Exemptions, based on plant type**			**Exemption, based on thresholds**		
		Peak load < 1500h	Nuclear	Geological storage	Useful waste heat	Distance	*Grounds provided*
Austria	√	√	×	×	√	√	√
Belgium	√	×	×	×	X	X	
Bulgaria	×						
Croatia	×						
Cyprus	√	√	√	√	√	√	×
Czech Republic	√	√	√	×	√	√	×
Denmark	√	√		√	√	√	×
Estonia	×						
Finland	√	√	√	√	√	√	×
France	√	√	√	√	√	√	×
Germany	√	√	√	√	√	√	×
Greece	√	√			√	√	√
Hungary	×						
Ireland	√				√	√	×
Italy	√	√		√			
Latvia	×						
Lithuania	×						
Luxembourg	×						
Malta	√	×	×	×	X	X	

Netherlands	√	√	√	√	√	√	×
Poland	√	√	√	√	√	√	×
Portugal	×						
Romania	×						
Slovakia	√		√				
Slovenia	√	√	√	√	√	√	×
Spain	√		√		×	×	
Sweden	√	√	√	√			
United Kingdom	√	√	√	√	√	√	√

Regarding the requested exemptions based on thresholds, thirteen MS included them. Some countries notified the application of exemptions based on thresholds without providing any figures of thresholds. The column of 'Grounds provided' show those countries that justified their thresholds providing some support to their request.

After a review of these notifications, the thresholds set fall into one of the following categories:

- Thresholds related to distance after a fixed distance;
- Thresholds related to total energy supply per year;
- Thresholds as a function of both distance and energy supplied;
- Thresholds related to total peak heat supply;
- Thresholds related to temperature of heat;
- Thresholds related to operating hours per year.

Few MS provided justifications or grounds to their setting of thresholds. A summary of the threshold values that MS included in their notifications is presented in Table 2.

Table 2 Summary of thresholds defined by Member States under Article 14.6 of the EED

Member State	Exemption 14(6)	Thresholds				
		Maximum Distance (km)	Minimum peak Heat (MW)	Minimum Heat supplied	Minimum Temperature (°C)	Minimum operating Hours per year (hours)
Austria	YES	5	1.5	50 TJ/yr	80	1500
Cyprus	YES					
Denmark	YES	5			Surplus of +10	1500
Finland	YES	5 – 20	20 – 80[1]		80	1500
Germany	YES		10			
Greece	YES			5.4 TJ/yr/km		
Ireland	YES					1500
Italy	YES					1500
Netherlands	YES			2.5 – 25 TJ/yr[2]		
Poland	YES	20	10%			
Slovakia	YES					
Slovenia	YES			5.4 TJ/yr/km		
Sweden	YES					
UK	YES	2 – 15[3]				

Section III of this report provides a comparison with benchmark threshold as well as a techno-economic model with the intention to evaluate the thresholds requested by MS and helps other MS to define their own thresholds.

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[1] Linked with distance threshold: 5 km for 20 MW;20 km for 80 MW

[2] Linked with distance threshold: <2.5 TJ/year for <3km; <25 TJ/year for >3km

[3] Linked with peak heat and per heating medium: for 0.5MW – 2.5 MW (water); for 2.5MW – 10 MW (steam)

3 Objective assessment of maximum feasible distance for heat transmission

The aim of this report is to provide a critical technical evaluation of the MS notifications. Special focus is on the setting of thresholds as low grade waste heat identified in industries and cogeneration potential found in power plants can only be exploited if there is an appropriate demand for it. Linking supply and heat demand areas is thus important for the utilization of waste heat and further integration of the energy sector. The viability of a low grade heat recovery project depends on whether the heat available can economically be transferred from the source to an identified sink. For the identification of the technical and economic potential of these heat links a techno-economic analysis has to be conducted, concluding to generic thresholds and rule of thumbs, related with the feasibility of such investments and so, providing arguments to exempt installations from the requirements of conducting a cost-benefit analysis of individual installations as stated by Article 14 (5).

For large central heat sources, as for example as a power station, heat will be transmitted in large hot water pipes. These pipes can be up to 1.5–2 metres in diameter, and be laid in multiples if necessary. For industries the amount of waste heat available will often be smaller than the one from power plants. It is evident that a new investment has to take place including the recovery/transforming of the desired amount of heat and the construction of a transmission line. As a result, there is a maximum distance that the investment will be viable. The identification of this distance is important for two reasons: firstly it can be used for the identification of potential utilization of waste heat from industries and cogenerated heat from power plants and, secondly it can be used to calculate a threshold that heat could be transmitted following the obligations of Article 14(6) of the EED. The following sub-sections examine current industry practices and expert literature and propose a model for the definition of this threshold in order to provide a critical technical and economic evaluation of MS notified thresholds.

3.1.1 Comparison with general benchmark thresholds

So far, there has been little discussion about the economic distance of heat transmission from the supply to the consumption point. Industrial heat is usually transported via water or steam but for this analysis only water will be considered. Low grade steam, at the temperatures usually used in modern district heating systems, has a large specific volume making the engineering and investment of such pipelines unattractive. Two phase flow caused by partial condensation of steam due to heat losses is also another concern in longer distance steam pipelines.

In literature studies and industry practice various distances have been observed related to heat transmission. A category of studies that do not mention any specific parameters but rather set a general threshold vary in the range of 10-30 km. More specifically, Persson et al (2012) use a limit of 30 kilometre motivated partly with reference to two current applications and Swedish experience and partly to avoid overestimations. Ma et al. (2009) while exploring other alternative transport options mention that the traditional ways to transport heat energy, which are normally based in the form of sensible or latent heat of water, are limited within small range of temperature (less than 300 °C) and distance (less than 10 km)

Hammond et al. (2014) used a flat distance threshold of 10 km for the estimation of the heat recovery potential in UK industries. In the same study it is mentioned that the possible distance of transportation and efficiency of the transfer is open to considerable uncertainty and that heat could be transported up to 40km. The main barriers for the heat transport were identified as the cost of heat pipelines, the security of supply, the existence of a heat network, and the regulation of such a market. Ammar et al. (Ammar, Joyce, Norman, Wang, & Roskilly, 2012) refer to a report of Terra Infirma, which concluded that steam with a temperature of 120–250 °C can be transported over approximately 3–5 km while water with a temperature of 90–175 °C can be transported over 30 km. For lower grade heat, other sources cited in that same report mentioned that 15 km is the economic limit.

In Helsinki, the Vuosaari power plant is connected to the central city area, by an approximately 30 km long tunnel, which is the longest continuous district heating tunnel in Europe.

In Denmark the distance from the CHP to the city centre of Aarhus is "only 20 km" and the length from the CHP to the other end is around 45 km. The total length of the transmission network which are continuously connected (not distribution) including a power station in one end, a waste incinerator along the line, and decentralised peak boilers is 130 km.

The longest bulk heat transmission distance in Europe is found in Czech Republic, Prague. It is the line from the Melnik power station to the centre of Prague, which length of pipe is some 67 km, although the direct distance is 32 km. This transmission pipe is for a large part on the surface. In other cases the transmission has been under large bodies of water (Joint Research Centre, 2012).

In Switzerland a nuclear power plant in Beznau, supplies 81 MW of heat through a 31 km main pipeline to various cities around it (AXPO, 2012). Another study for a Swedish industrial plant assumes a 30km distance to the nearest district heating network (Svensson, Jönsson, Berntsson, & Moshfegh, 2008).

Moreover, there is a large category of new studies that explore the transmission of bigger amounts of heat in various temperatures:

- Safa (2012) states that new developments in insulation and pumping technologies may give hope in a near future for applications over long or even very long distances (>100 km). In his case study a 150 km long main transport line exhibits losses representing less than 2 % of the total transported power.
- A case study from Fortum Corporation for Loviisa Nuclear power plant concluded that available heat to be transported to the eastern Helsinki which is about 80 km away ca reach up to 1 GW. The location of the Loviisa site at the southern coast of Finland approximately 75 km east of the Helsinki metropolitan area with one million inhabitants offers a good opportunity for large-scale district heat generation for the region from the Loviisa 3 unit (Tuomisto, 2013).
- Even bigger amount of heat (2 GW) was considered in the work of William Orchard Partners London Ltd., using 2 x 2m diameter pipes. The cost of transferring this amount of heat to 140 km is about EUR 0.0035/kWh for the delivered heat. Heat loss was 35 MW and the pumping losses 50 MW meaning the heat would actually arrive warmer than when it left the power station (Joint Research Centre, 2012)
- Kapil et al. (2012) developed a model that takes into consideration capital costs market heat purchase price and heat losses. For his study considering 62 MW of low grade heat, he concluded that the break-even point for economic distance to heat transfer for his case is 86.5 km, with the assumption that 1 % of heat is lost from the source to the DH network. However, the operating cost for pumping has not been considered in this simple calculation for the feasible distance of heat transfer.

Other options explored in the literature for long distance transfer of low temperature heat energy include other technologies that are not based on the transfer of sensible heat. The following technologies have been considered: chemical reactions, phase change thermal energy storage and transport, hydrogen-absorbing alloys, solid–gas and liquid–gas adsorption (Ma et al., 2009). Sorption processes are efficient heat transportation systems. The main advantage of such systems compared with traditional transport systems is that the heat is transported by a reactive fluid at ambient temperature which limits thermal losses. As a result, no pipeline insulation is needed. However these alternative technologies do not yet have the technical/economic maturity to be linked with exemptions under EED Art. 14(6) and thus will not be considered in this report. Business plans that include these technologies should conduct a detailed CBA.

It is clear that the maximum feasible distance depends on several factors. It is a function of site-specific parameters (quantity and quality of heat), market conditions (electricity and heat price), climate data (ambient temperatures, heating season etc.) and design data (pipe material and diameter and efficiency of its insulation). However, the literature review indicated that feasible distance is usually estimated by empiricism or by using few of the abovementioned parameters with the lack of a methodological tool to estimate this distance based on actual generic data.

3.2 Development of a demand-distance model for thresholds evaluation

The scope of this work is to develop a detailed techno-economical model to be used for the estimation of heat transport costs including all major capital and operating expenditures associated with this project while considering all above parameters. This model will be used to identify the maximum economically feasible transmission distance by solving it iteratively to a specified economic criterion. Case studies are also presented covering typical technical and economic parameters found in literature and industry practice, along with a comparison with the notified MS's thresholds.

The proposed model structure is presented in Figure 1. The main input to this model is the heat supplied and the transfer distance. The calculations are split into two main parts. The first part (technical model) estimates the required equipment needed for the recovery and transmission of the heat (pipes, heat exchanger, insulations etc.) as well as the energy needed for this transfer. The second part estimates all costs involved based on the results of the first part of the model. The design variables are subject to optimization and usually if not enough data are available they are selected based on rules of thumbs and best available practices. Technical properties and market data (prices, rates) involved are also necessary for the estimation of the model. In the following sections guidance will be given for the selection of the most appropriate values of these variables. The result of this model is the net present value of the investment. Modifying the distance and solving numerically this model for NPV = 0 will give the maximum economically feasible distance.

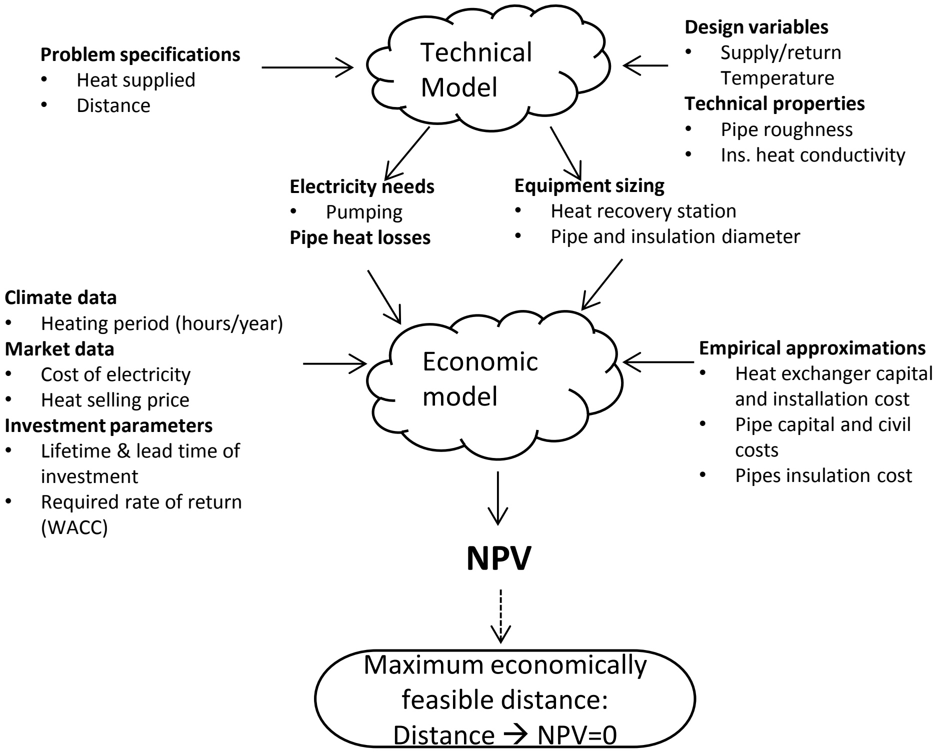

Figure 1. Model structure.

Since the model refers only to industries, it is assumed that the heat recovered has no other impact on the plant since if it wasn't recovered it would be dissipated to the environment; this amount of energy is available for free. Thus, there are no other operating costs involved in the industry side apart from the operation of the O&M heat exchanger for the recovery of heat. The model can be however generalized further to include power plants or cost of transforming heat to useful temperature.

3.2.1 Mathematical formulation

The equations describing the proposed model are analysed in the following two sections.

3.2.1.1 Technical model

Before equipment capital and operating costs can be estimated, it is necessary to determine equipment size from basic material and energy balances. Each problem is specified according to the variables mentioned in Table 3:

Table 3. Problem specification variables.

Problem Specifications		Units
Q	Heat transferred	MW
L	Distance (Pipe length)	m
Ts	Soil Temperature	°C

Q depends on the heat available in the required temperature by the end consumer. L will be solved numerically for NPV=0 which will correspond to the maximum feasible distance.

The variables showed in Table 4 depend on the design of the district heating network. The availability of the waste heat is an important constraint to the definition of this parameter. Usually for a 3rd or 4th generation district heating network heat at around 80 – 120 °C has to be available at the entry point of the central distribution station of the network.

Table 4. Design variables.

Design variables		Units
Th	Supply Temperature	°C
Tc	Return Temperature	°C
s	Insulator thickness	mm
ε	Pipe roughness	

Table 5 show the variables that are estimated by the model.

Table 5. Model variables.

Estimated Variables		Units
V	Volumetric flow rate	m^3/s
μ	Viscosity	Pa s
ni	Kinematic viscosity	m^2/s
Re	Reynolds number	-
f	Friction factor	-
DP	Pressure loss	%
Qlsp	Specific heat loss	W/m
hi	Insulator conductivity	W/m K
Ql	Heat losses	MW
Ep	Pumping energy	MWe
Vi	Insulation used	m^3

Pumping needs

The pipe diameter *Dh* is usually an optimization parameter but in this model it is estimated using a rule of a thumb as a function of volume flow (see Annex). Knowing this, the basic characteristics of the fluid flow can be estimated (volume flow, viscosity, laminar/turbulent type of flow).

In order to calculate the pumping needs, the pressure drop along the pipe has to be estimated. Darcy–Weisbach equation is a phenomenological equation, which relates the pressure loss due to friction along a given length of pipe to the average velocity of the fluid flow. The dimensionless friction factor *f* (Darcy friction factor), is estimated by means of Colebrook–White equation. Knowing the pressure drop and the pump efficiency, the electricity consumed in the pump can be estimated by applying the equations on Table 6.

Table 6. Equations of the pumping model.

$$V = \frac{Q}{\rho\left(\frac{Th+Tc}{2}\right)\cdot Cp\cdot (Th-Tc)}10^3$$

$$ni = \frac{\mu(Th)}{\rho(Th)}\cdot 10^3$$

$$A = \pi\left(\frac{Dh}{10^3\cdot 2}\right)^2$$

$$Re = V\cdot\frac{Dh}{ni\cdot A\cdot 10^3}$$

$$\frac{1}{\sqrt{f}} = -2\ \log_{10}\left(\frac{\varepsilon}{3.7Dh}+\frac{2.51}{Re\sqrt{f}}\right)$$

$$DP = f\cdot\frac{L}{Dh\cdot 10^3}\cdot\frac{\rho(Th)\cdot\left(\frac{V}{A}\right)^2}{2}$$

$$Ep = 2\cdot DP\cdot\frac{V}{np}10^{-6}$$

Heat loss

The pipe heat transfer equation that estimates the heat loss is estimated by means of:

$$Qlsp = 2\pi\cdot\frac{hi}{LN\left(1+2\frac{s}{Dh}\right)}(Th-Ts)$$

$$Ql = Qlsp\cdot L\cdot\ 10^{-6}$$

The insulator thickness (*s*) is usually estimated by optimization depending on the amount of heat and pipe diameter. For the examined ranges the optimum *s* can vary around 50 – 200 mm. Total volume of insulation needed is given by means of:

$$Vi = \frac{\pi}{4}\cdot((Dh+s)^2-s^2)10^{-6}\cdot L$$

Heat recovery station

A heat exchanger is used for the recovery of heat. The type depends on the temperature range, source of waste heat, type of heat exchange (gas-liquid, liquid-liquid etc) and to other specific requirements (e.g. avoidance of cross-contamination).

Usually heat exchangers are sized (and priced) by the total heat exchange surface. The following heat transfer equation can be used:

$$Ahx = \frac{Q}{Uhx\cdot LMTD}$$

where *Uhx* is the overall heat transfer coefficient and LMTD the log mean temperature difference of the heat exchanger estimated by means of:

$$LMTD = \frac{(T_{1H} - T_{1C}) - (T_{2H} - T_{2C})}{\ln \frac{(T_{1H} - T_{1C})}{(T_{2H} - T_{2C})}}$$

where T_{1H} is the hot stream input temperature, T_{2H} hot stream output temperature, T_{1c} cold stream input temperature, T_{2C} hot stream output temperature. The selection of the appropriate U is usually a function of the fluids inside the heat exchanger. The following values can be used when no other information is available: water/liquid condensers: 750 W/m^{2}K; liquid/gas, gas/gas, 25 W/m^{2}K.

3.2.1.2 Financial model

Using the sizing variables from the previous section the capital and operating costs can be estimated. The main variables are presented in Table 7 and the equations of the financial model in Table 8.

Table 7. Variables of financial model.

Variables		Units
Chr	Heat recovery station capital costs	M$
Cpi	Piping costs	M$
Cin	Insulation cost	M$
Cla	Civil work costs	M$
Ctot	Total overnight capital costs	M$
cfh	Capacity factor of transmission line	%
Qsold	Total heat sold	M$
Eused	Total electricity used	GWh(th)
Cop	Operating costs	M$
TAR	Total Annual revenues	M$
CF_t	Cash Flow for year t	M$

Table 8. Financial model description.

Equations
$Ctot = Chr + Cpi + Cin + Cla$
$Qsold = \ Q \cdot cfh \ \cdot 10^{-3}$
$Eused = Ep \cdot 8760 \cdot cfh \ \cdot 10^{-3}$
$Cop = \ Eused * Cel$
$TAR = Pth \cdot Qsold$
$CF = TAR - Cop$

The annual cash flow is summed over *Le* years to get the cumulated cash flow by means of:

$$NPV = Ctot + \sum_{t=0}^{Le} \frac{CF_t}{(1+i)^t}$$

In order to find the maximum economic transmission distance the model is solved iteratively till NPV=0. The selection of the discount rate (*i*) depends on the required return for the equity as well as the bank loan interest rate. Usually in feasibility analysis, the weighted average cost of capital (WACC) is used in order to simplify the estimations. The level of accuracy is not so high and the scope of these studies is generic so there is no need to describe a detailed investment scheme.

3.2.2 Model results and discussion

The proposed model has been applied for a typical case using the parameters in Table 9. The results are presented in Figure 2. The curves follow the power law formula ($f(x) = aX^n$) and when plotted in a log-log plot form straight lines. The range of waste heat expected to be applicable to industries ranges on the left side of the axis (1 – 100 MW); bigger amount of energy transmitted will be usually available from CHP power plants. Depending on national and market conditions the proposed model can be used to estimate and justify a country specific threshold.

Table 9. Parameters used.

Variable	**Name (units)**	**Central value**
Soil Temp	*Ts (°C)*	15
Supply Temperature	*Th (°C)*	100
Return temperature	*Tc (°C)*	60
Pipe Roughness height	*E (-)*	0.2
Insulator conductivity	*hi (W/m K)*	0.05
Insulator thickness	*S (mm)*	200
Cost of insulation	*Csin* ($€/m^3$)	100
Capacity Factor	*Cfh (%)*	40%
Lifetime	*Le (years)*	20
Discount rate	*i*	12%
Heat Selling price	*Pth (€/kWh)*	0.03-0.06

The following two effects are observed: as the amount of heat transmitted increases the optimum economic diameter of the pipe increases as well. In a bigger pipe, the fraction of heat lost becomes smaller, since the heat loss surface area in relation to the total volume of fluid gets smaller. Moreover, the materials needed per unit of transferred fluid are also reduced, which results to smaller the specific capital costs. This is because the carrying capacity of the pipe increases in proportion to the square of the diameter whereas the pipe cost increases only in proportion to the diameter.

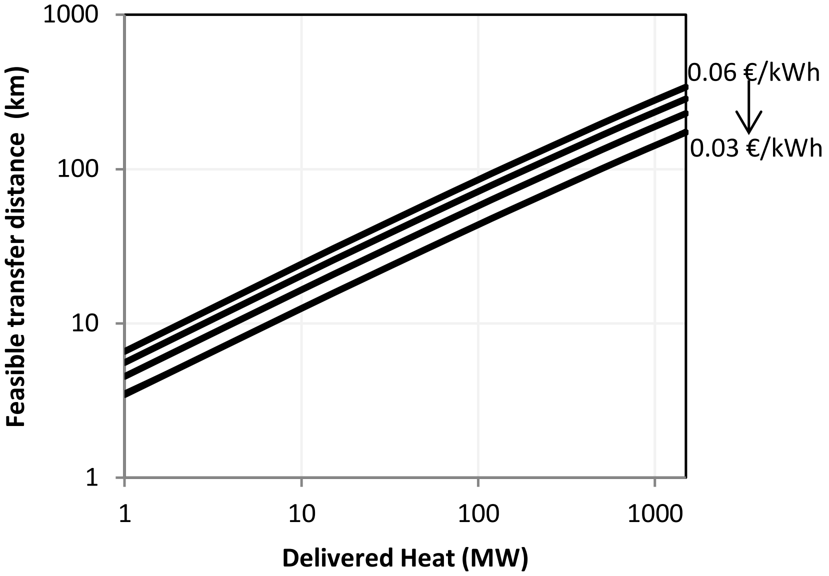

Figure 2 Indicative results of the model for various heat selling prices

The effect of delivered Temperature on the maximum feasible delivery distance is also examined. Figure 3 illustrates the maximum feasible distance contours for different temperatures and heat quantities for a low (0.04 EUR/kWh) and a high (0.08) heat market price.

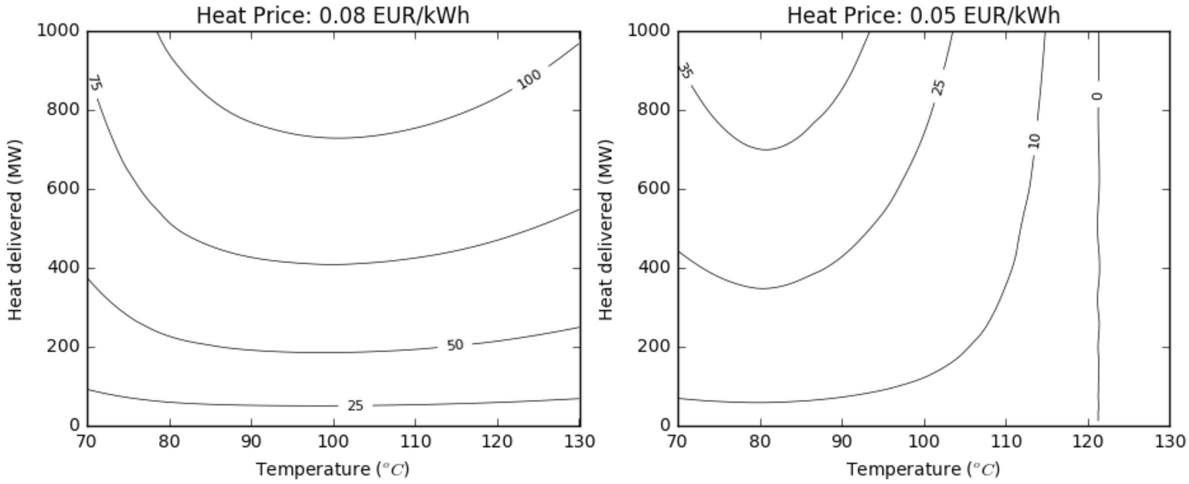

Figure 3 Effect of heat quantity and quality on maximum feasible distance (contours in km) for two different heat market prices

Figure 4 shows a comparison between the notified MS thresholds based on both heat and distance and two extreme estimates of the model as defined in Table 10. These MS thresholds fall within these two extremes and most of them are closer to the more high scenario showing that the notified thresholds are realistic and in line with current practice.

Table 10 . Basic parameters for two extreme scenarios.

Variable	High Scenario	Low Scenario
Price of electricity (€/kWh)	0.04	0.10
Price of heat (€/kWh)	0.08	0.03
Capacity factor of heat line (%)	50%	20%
Discount rate (%)	8%	15%

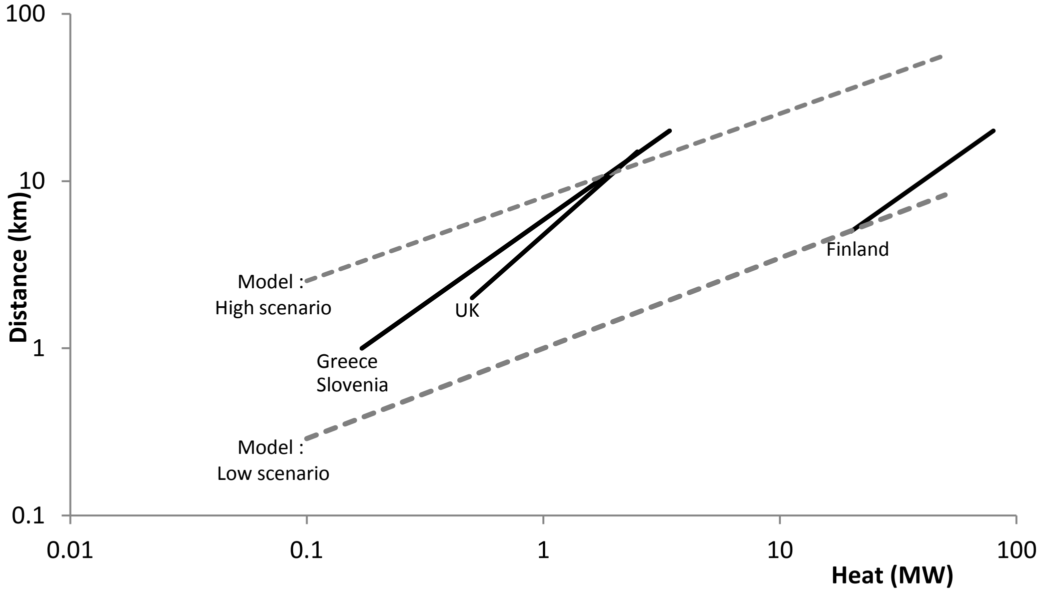

Figure 4 Comparison of model results with notified thresholds.

The model provides for a tailored approach and can be used for different magnitudes of distances and waste heat. Based on these results and considering that thresholds ought not to a priori exclude feasible heat linking options, the recommended absolute minimum consideration is to satisfy at least the extreme values, as presented in the high scenario. The following fitted equation is proposed as an absolute minimum consideration:

$$Maximum\ Feasible\ Distance(km) \ = \ 8 \cdot \sqrt{Energy(MW)}$$

Thresholds approaching the low scenario curve, could be applied depending on the specific country conditions. For reference the fitted equation of the low scenario as indicated in Table 11 is the following:

$$Maximum\ Feasible\ Distance(km) \ = \ 1.5 \cdot \sqrt{Energy(MW)}$$

4 Evaluation and conclusions

As demonstrated with the techno-economic model the thresholds for economic heat transmission, which exempts installations from the requirements of conducting a cost-benefit analysis, should consist of distance, amount of heat, temperature, and annual operating time.

Within the group of MS that provide exact figures for thresholds, different approaches can be distinguished. Most thresholds were based on fixed values for distance, waste heat, as done by Poland, Demark and Austria, Netherlands. This approach does not consider that larger amount of available heat can be economically transferred longer distances. In some cases the thresholds were based on a relation between distance and available heat, as done by Slovenia, Greece, UK and Finland. This approach is more appropriate as it considers that higher available heat can be transferred to longer distance. However in this case a link to other parameters is missing (temperature, availability). E.g. there may be an industrial facility beyond those thresholds that will be operating seasonally only for a couple months per year. In this case this facility will not be able to exempt from a CBA. A few other details have been also indicated such as temperatures and operating hours per year.

It has also been observed that in most cases the distance thresholds are too conservative. They usually fall into the range of 5 – 20 km whereas literature current practices and preliminary analysis show that bigger distances can be economically viable. As a consequence, heat linking opportunities might be missed. The same can be observed for the peak heat: e.g. Germany indicates that an installation with less than 10 MW of waste heat should exempt from a CBA whereas a nearby located heat consumer could benefit from it.

Ideally the thresholds notified should be properly documented. This can be achieved by following a similar approach to what was demonstrated in this report by correlating at least the distance with the available heat to be delivered. Alternatively, if there is lack of information the generic rule of thumb formula of this report could be used as a generic guideline.

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List of abbreviations and definitions

CA	Comprehensive assessment of national heating and cooling potentials;
CBA	Cost Benefit Analysis;
CDD	Cooling degree days;
CSWD	Commission Staff Working Document (2);
DH/DC	District heating and cooling;
CHP	Combined heat and power
EED	Energy Efficiency Directive (1);
HDD	Heating degree days;
MS	Member states;
NPV	Net Present Value

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