EU Energy Efficiency Directive

Development and Review of Cost Benefit Analysis Exemption Thresholds as required by Article 14(6)

1 Introduction

The following note details work conducted by Ricardo-AEA to develop thresholds as permitted under Article 14(6) of the Energy Efficiency Directive (EED[1]) exempting parties from the requirement to conduct a cost benefit analysis (CBA) relating to the recovery of waste heat from industrial installations and its use to meet economically justified demands.

2 Background

Article 14 paragraph 5 of the EED requires that a Cost Benefit Analysis (CBA) be carried out in particular instances occurring after 5th June 2014. Two of the four instances identified are:

Article 14(5)(c) An industrial installation with a total thermal input greater than 20MW (GCV) is either planned or is substantially refurbished. Purpose of CBA is to consider the possibility of using waste heat to satisfy economically justified demand, including through cogeneration or connection of the installation to a district heating/cooling network.

Article 14(5)(d) A new district heating/cooling network is planned or an existing network has an energy production installation with a total thermal input greater than 20MW (GCV) that is either new or substantially refurbished. The purpose of the CBA will be to consider the cost and benefits of utilising the waste heat from nearby industrial installations.

Paragraph 6 advises that Member states will be permitted to 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 to exempt individual instances listed above from the need to conduct a CBA.

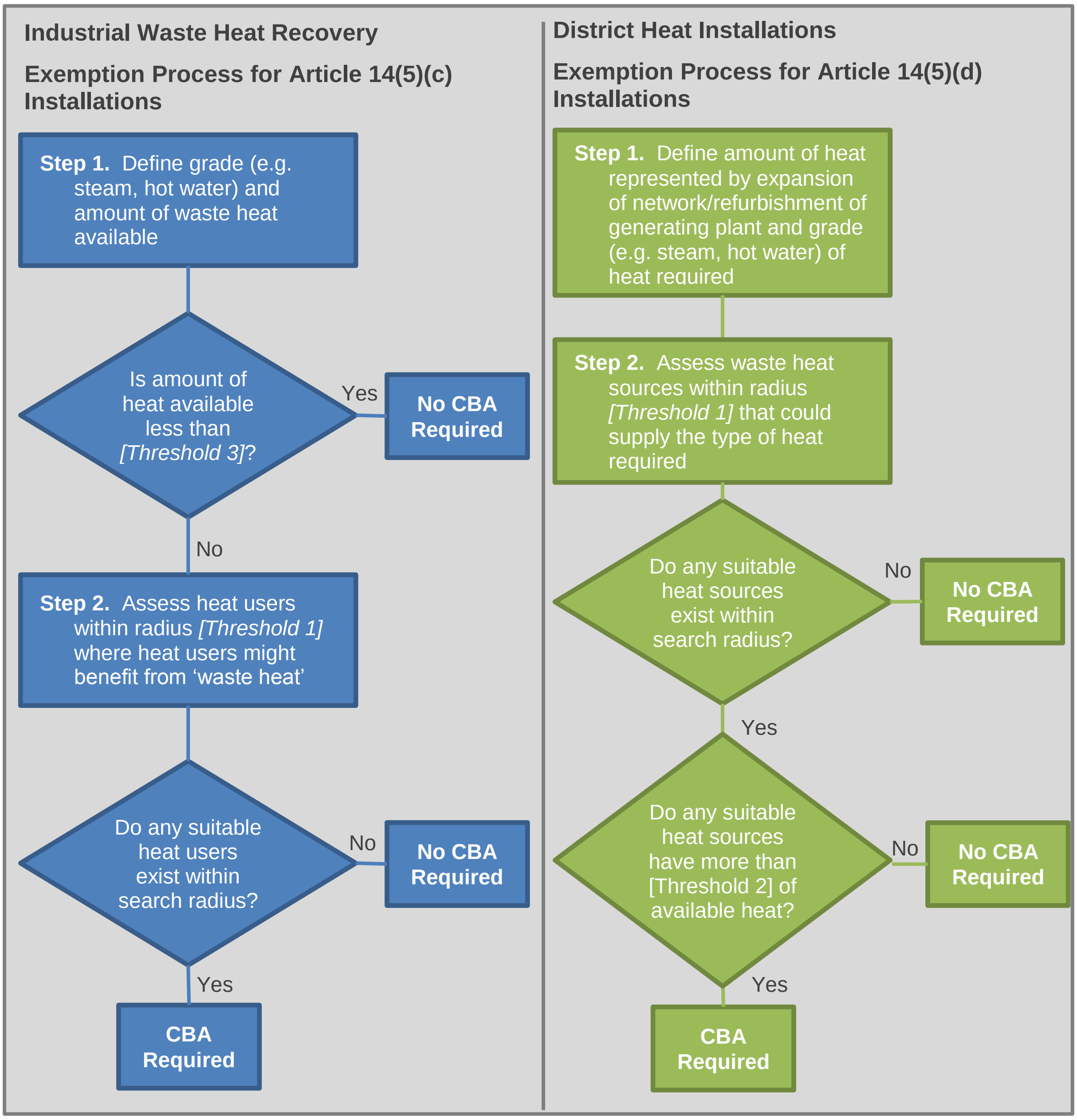
In light of this, Ricardo-AEA developed appropriate thresholds expressed in terms of:

1) Maximum distance between a waste heat source and heat user. If the distance identified between the source and user is greater than this distance, then a CBA should not be required.
2) Minimum amount of heat demand associated with a heat user that would be considered appropriate to warrant connecting to a waste heat source. If the demand presented is less than this value, then a CBA should not be required.
3) Minimum amount of available waste heat that is considered worth recovering and supplying to heat users. If the amount of available waste heat is less than this value, then a CBA should not be required.

The following flow diagrams provided in Figure 1 provide an indication of the likely exemption processes that would be employed by the Regulator.

[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, Amending Directives 2009/125/EU and 2010/30/EU and repealing Directives 2004/8/EC And 2006/32/EC

Figure 1 Flow Diagrams for Article 14(5)(c) and (d) Exemption Processes

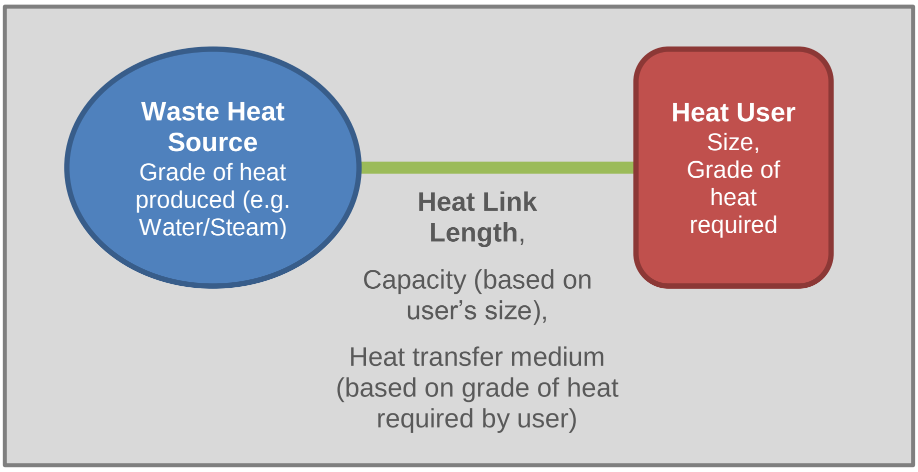


3 Methodology

The objective of the exercise is to establish threshold values to allow the exemption assessment procedures outlined in Section 1 to be administered. In principle, the threshold values should represent the point that at which a heat linking scheme would cease to be economically viable even under the most favourable conditions. As such, any schemes that exceed the thresholds could be considered to be highly unlikely to be economically viable. While schemes that do not exceed these thresholds may also not be economically viable due to project-specific reasons, it would require the more in-depth analysis represented by a full cost benefit analysis to establish this.

A series of Discounted Cash Flow (DCF) analyses have been conducted to determine the economic viability of generic heat linking schemes. The schemes considered represent the cheapest and simplest form of heat linking project, that being a point-to-point connection between a single heat source and a single heat user. This concept is presented in Figure 2 together with the principal parameters describing the model.

Figure 2 Point-to-Point Heat Link Concept



The DCF analysis is repeated to assess how the net present value (NPV) of a link of a particular capacity would vary with changes in length. This would also need to be repeated for a range of different capacities and grades of heat as these will also be expected to influence costs and benefits. Using these profiles it would be possible to identify the critical length over which the transfer of heat would cease to become economically viable (i.e. NPV becomes zero). This length in turn would inform the radius of the search area around the heat source for potential heat users.

In conducting the DCF analysis, it is intended that assumptions applied reflect the most favourable conditions otherwise the analysis will not represent the extreme limit of economic viability and could lead to the exemption of schemes that may in fact be economically viable under favourable conditions. As such the analysis will consider the 'best case scenario', meaning the most favourable conditions under which to assess economic viability.

3.1 DCF Analysis

The discounted cash-flow (DCF) analysis takes into account the additional cost and revenue streams associated with the recovery of heat from the heat source and its provision to the heat demand by means of the heat link. The analysis has been considered from the standpoint of an operator of a heat source who has made the capital investment in the heat link and will sell the recovered heat onto the heat user[2]. The analysis is based on the assumption that responsibility for operating the heat link lies with the operator of the heat source but the heat user is responsible balancing their heat demand with other sources (e.g. from top-up/back-up gas boilers).

3.1.1 Additional Costs Considered in DCF Analysis

On the above basis, the DCF analysis must take into account the following costs associated with the heat linking project.

- **Capital Costs for Heat Link.** This covers the following two sub-elements:
  - **Modification Costs for Recovering Waste Heat.** This element covers costs associated with modifications to the heat source in order to permit waste heat to be recovered in a usable form. Covers material and installation cost for items such as heat exchangers, circulating pumps and associated electrical works.
  - **Distribution Pipework Costs.** Covers the cost of materials and installation for a set of distribution pipes running between the heat source and the heat user.

[2] While alternative delivery models exist (e.g. heat link established by a third-party developer who purchases heat from heat source and sells this on to the heat user) the cost of the distribution link would still be accounted for (e.g. through a reduced price for heat paid by the developer to the heat source). These alternatives were not considered further as they would introduce additional complexity into the analysis without providing any corresponding benefits

- **Heat Link Operating and Maintenance Costs.** This covers the following sub-elements:
    - **Maintenance Costs for Recovery and Distribution Costs.** Covers costs associated with the maintenance and upkeep of the heat link.
    - **Electricity Costs for Circulation of Heat Transfer Fluid.** Covers cost of electricity consumed by circulating pumps.

As the heat user retains responsibility for balancing heat supplied by the link with demand, the DCF analysis does not take into account capital costs for top-up or back-up boilers or fuel for such plant.

3.1.2 Revenue Streams Considered in DCF Analysis

The sole revenue source for the heat linking scheme is taken to be that derived by the sale of heat to the heat user. The sale price for heat is taken to be 10% less than the cost of sourcing heat from conventional sources such as on-site gas boiler.

3.2 Model Data and Assumptions

The following section lays out the data and assumptions used in the DCF analysis.

DCF Model Parameters

- The investment lifetime is 20 years
- The discount rate is 6%

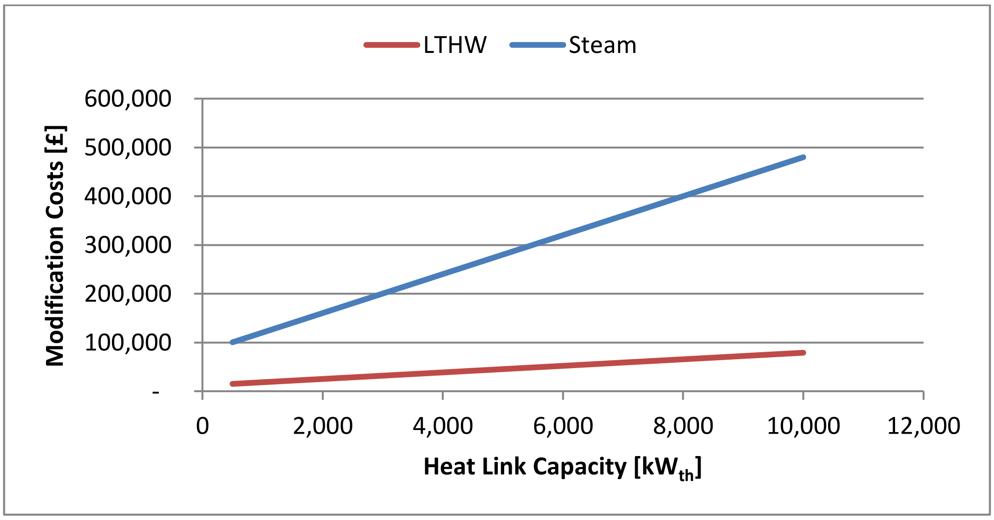
Heat Source Operation

- The model assumes that the heat link operates with a load factor of 80%, equivalent to operating at full capacity for 7,008 hours per year.

Heat Link Capital Cost

- The capital cost of the heat link is composed of two elements:
    - Cost of modification for the heat source to recover the waste heat and circulate it between the heat source and the heat user. This cost is determined based on the heat transfer medium (either steam or water) and the capacity of the heat link, which in turn is based on the size of the heat user's demand[3]. The modification cost profiles adopted for the model are given in Figure 3.

Figure 3 Modification Cost Profile

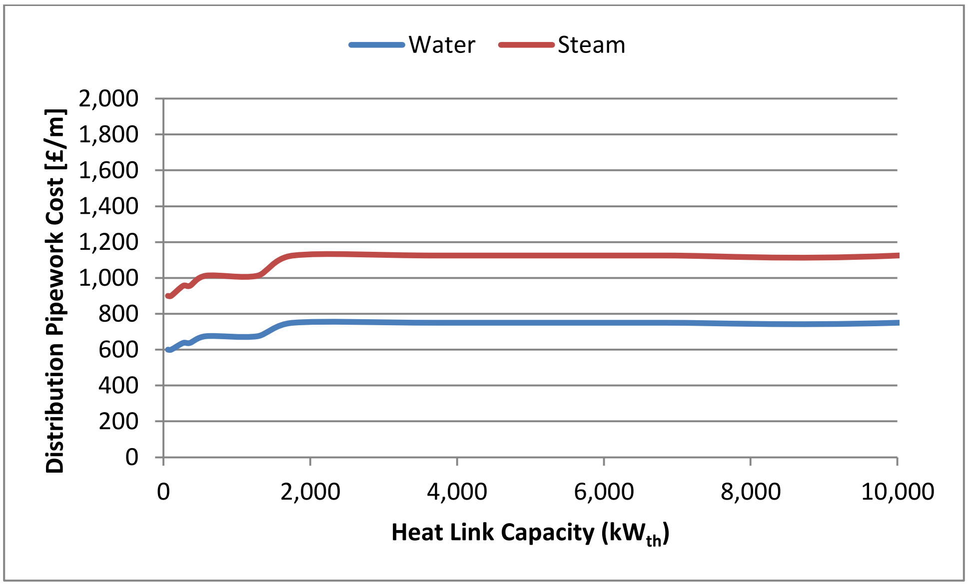


Source: Ricardo-AEA

[3] It has been assumed that the modification costs consist of costs for the installation of heat recovery equipment (e.g. heat exchangers) and circulation pumps, which could be installed incrementally to match the capacity of the heat link. However, it is possible that some processes may require further modification works, requiring the modification/replacement of major plant items so that the costs of modification would be dictated by the size of the heat source, potentially making them substantially higher. However, this assumption was not adopted in the DCF analysis as it may not apply to all processes and would not represent the most favourable conditions for development.

○ Distribution pipework costs. This cost is determined based on the transfer medium and heat link capacity to give a cost per unit length. The distribution pipework cost profiles adopted for the model are given in Figure 4. It should be noted that cost data for steam distribution pipework has proved difficult to obtain and, as a result, the steam cost profile is based on the profile for water and multiplied by a factor of 1.5 to reflect the more expensive materials and higher grades of thermal insulation that would be required for a steam installation while also recognising the reduced material requirements as a result of the higher energy density of the steam. Both cost profiles include labour costs on the basis of buried installation in normal open ground conditions (i.e. not including extra costs associated with ground clearance and the removal/reinstatement of hard surface coverings).

Figure 4 Distribution Pipework Cost Profile



Source: Ricardo-AEA[4]

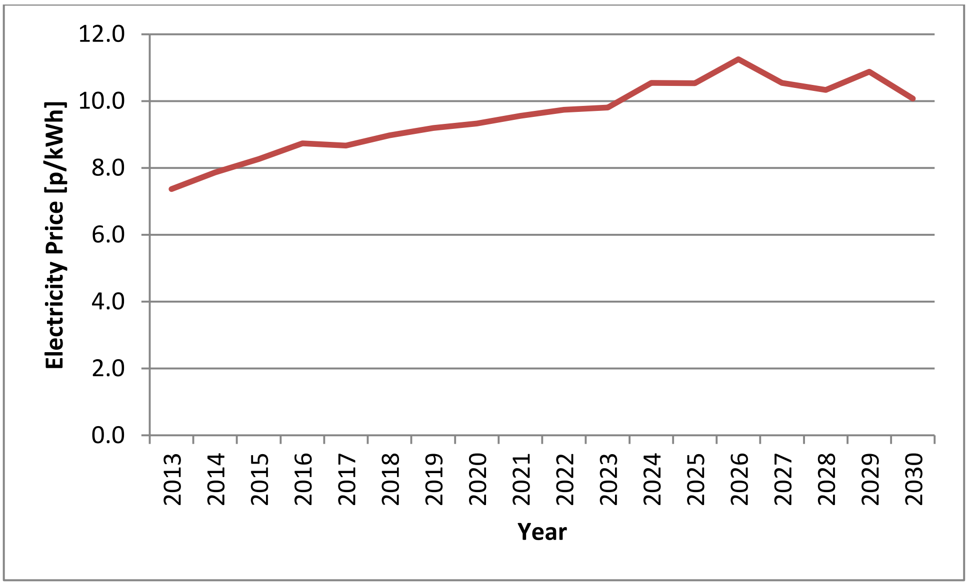
Operation and Maintenance of Heat Link

- Responsibility for balancing the heat user's demand is assumed to lie with the heat user themselves. As such the heat link does not incorporate any form of back-up or top-up heat generation plant.
- Heat losses in the distribution of heat from the heat source to the heat user are assumed to be 10%.
- Annual costs for operation and maintenance of the heat link are assumed to be 5% of heat link capital costs.
- Heat is assumed to be circulated around the heat link by means of a series of electrically-driven pumps with energy consumption by these pumps equal to 2% of the energy transferred along the link. The electricity price profile used is based on the prices used in DECC UEP modelling[5] and is presented in Figure 5 below.

[4] Data was derived from work conducted by Ricardo-AEA for the Scottish Government relating to the heat-linking of thermal power stations.

[5] Industrial Retail electricity profile, Low Price Scenario, UEP October 2012

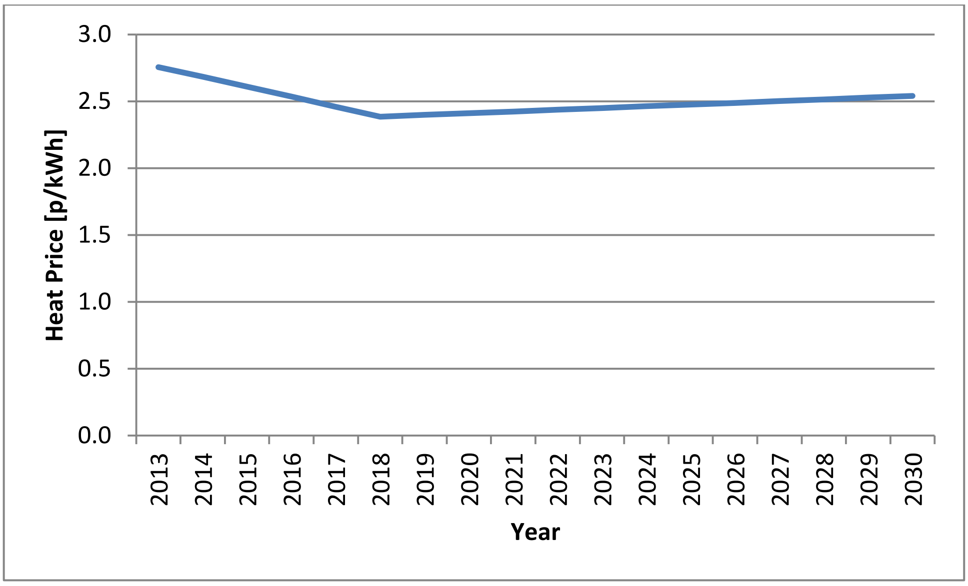
Figure 5 Electricity Price Profile



Price of Heat

- The price of heat charged to the heat user is presented in Figure 6. Prices have been determined on the basis of them being 10% less than the equivalent cost of heat from an on-site boiler with an efficiency of 81% (gross CV basis)[6]. The fuel cost used in this calculation is based on the prices used in DECC UEP modelling[7].

Figure 6 Price of Heat Profile



[6] The 81% reference efficiency is based on the current efficiency reference value for separate heat production from natural gas referred to in the Energy Efficiency Directive. This value is 90% on a net CV basis, which equates to 81% on a gross CV basis.

[7] Industrial Retail natural gas profile, Low Price Scenario, UEP October 2012

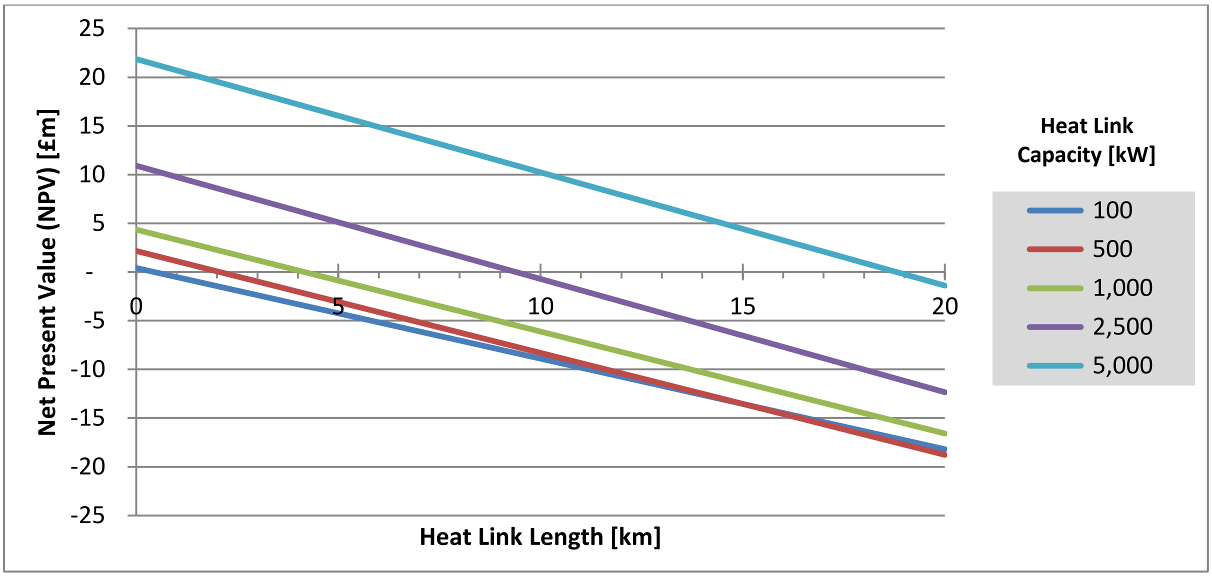
4 Results

The DCF analysis was repeated considering a series of heat links of varying capacity and using both water and steam as heat transfer medium.

Heat Links using Water as Heat Transfer Medium

Water based heat links were considered with capacities of $100kW_{th}$, $500kW_{th}$, $1MW_{th}$, $2.5MW_{th}$ and $5MW_{th}$. The results of modelling are presented in Figure 7 below.

Figure 7 DCF Analysis Results for Heat Links using Water as Heat Transfer Medium

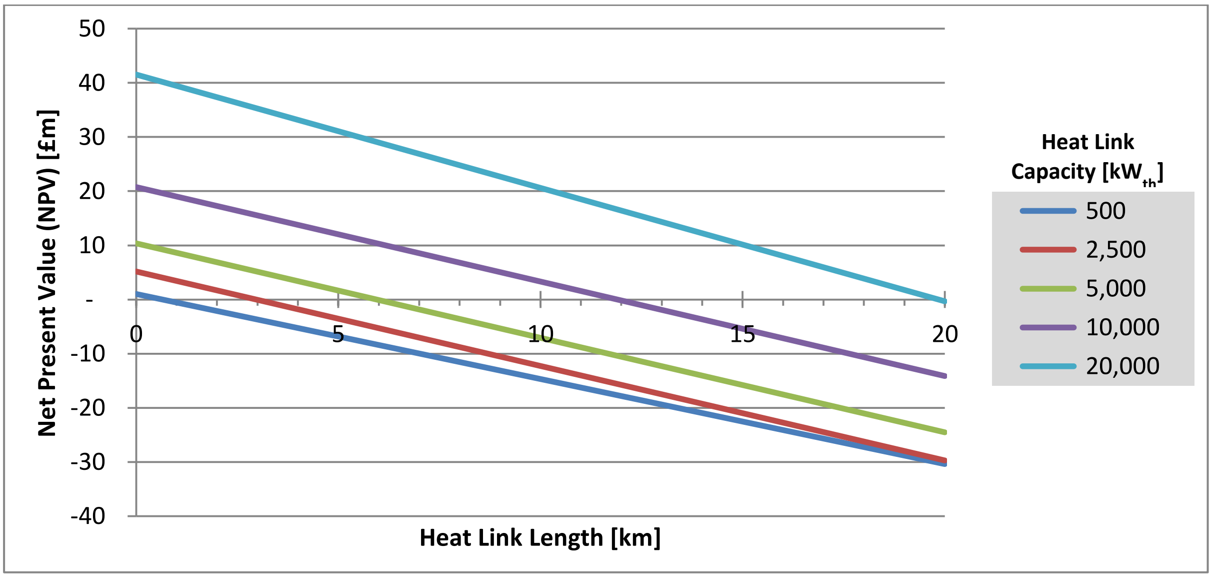


As anticipated, it was found that the NPV for all heat links decreased with increasing length due to the increases in capital costs. It was found that the length at which each heat link ceased to be economically viable (i.e. NPV fell to zero) was 400m for the $100kW_{th}$ capacity heat link, 2km for the $500kW_{th}$ link, 4km for the $1MW_{th}$ link and 9km for the $2.5MW_{th}$ link. The $5MW_{th}$ link was found to remain economically viable for lengths up to 19km.

Heat Links using Steam as Heat Transfer Medium

Steam based heat links were also considered with capacities of $500kW_{th}$, $2.5MW_{th}$, $5MW_{th}$, $10MW_{th}$ and $20MW_{th}$. The results of modelling are presented in Figure 8.

Figure 8 DCF Analysis Results for Heat Links using Steam as Heat Transfer Medium



In general terms, the critical lengths for steam-based heat links were less than for an equivalent capacity link using water due to the higher capital costs associated with steam-based links. The critical lengths were 500m for the 500kW$_{th}$ link, 3km for the 2.5MW$_{th}$ link, 6km for the 5MW$_{th}$ link and 12km for the 10MW$_{th}$ link. The 20MW$_{th}$ link was found to be economically viable for distances up to 20km.

5 Discussion and Recommendations

Current environmental permitting guidance from the Environment Agency for Large Power stations require that the applicant must consider existing and planned opportunities for heat supply within a radius of 15km from the proposed plant locations. While the results from modelling indicate that large capacity heat linking schemes could in principle be economically viable for distances greater than 15km, it is our recommendation that the 15km figure be used as the maximum search radius in order to maintain consistency with this guidance.

In light of this it is recommended that the following framework be considered with regards to setting thresholds under Article 14(6) of the EED.

Threshold Value 1 - Search Radius

The search radius (Threshold value 1) is determined based on the capacity of the heat source/heat demand and is given in Table 1 below, which is based upon the limiting distances for economic viability derived from the DCF analysis performed.

Table 1 Proposed Values for Threshold 1 (Search Radius)

Grade of Heat	Capacity of Heat Source / Heat Demand [kW$_{th}$]	Max Search Radius [km] (Threshold 1)
Water	>100kW and ≤500kW	2
	>500kW and ≤1MW	4
	>1MW and ≤2.5MW	9
	Greater than 2.5MW	15
Steam	>500kW and ≤2.5MW	3
	>2.5MW and ≤5MW	6
	>5MW and ≤10MW	12
	Greater than 10MW	15

Threshold Value 2 (Minimum Heat Demand) and Threshold Value 3 (Minimum Available Waste Heat)

The proposed values for Thresholds 2 and 3 were both determined based on the capacities at which heat links would be economically viable only over very short distances (less than 1km). These values are presented in Table 2.

Table 2 Proposed Values for Thresholds 2 and 3 (Minimum Heat Demand/Minimum Available Waste Heat)

	Water	Steam
Minimum Heat Link Capacity (Thresholds 2 and 3)	100kW$_{th}$	500kW$_{th}$

Criteria for Identifying "Suitable" Heat Users/Sources

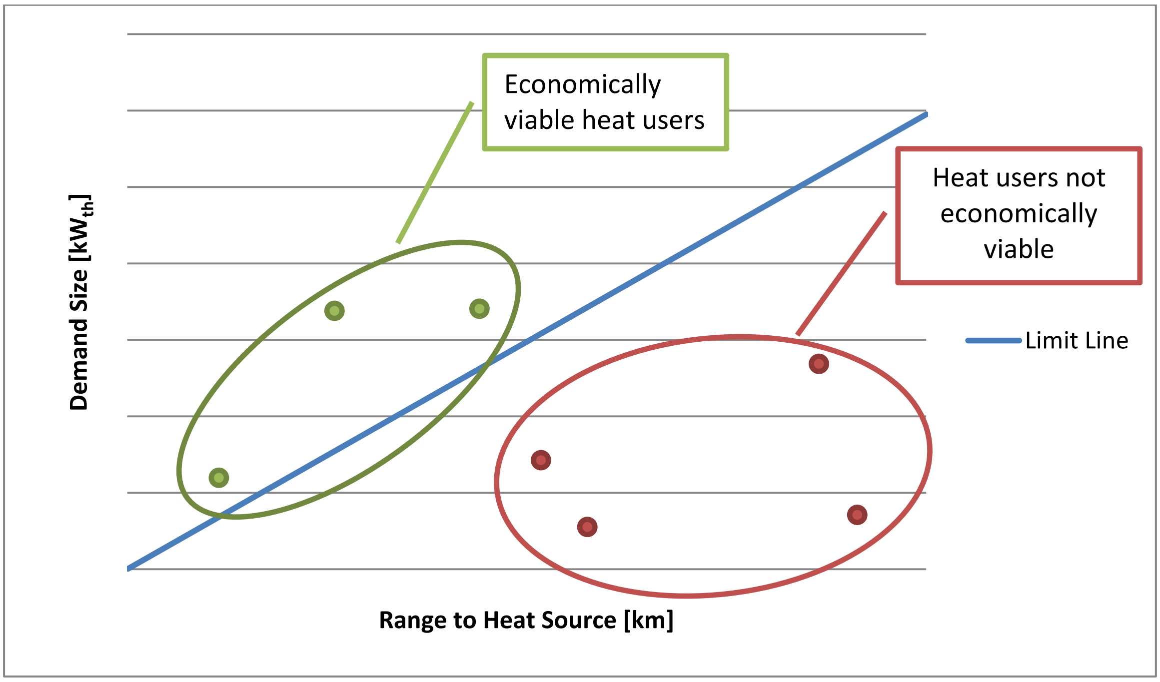
The exemption procedures set out both refer to the need for the party seeking the exemption to determine if any "suitable" heat users/sources exist within the search area.

A key consideration in determining suitability of a heat source/heat user will be confirming the compatibility of the grade of heat required by the user with that produced by the heat source. In doing so it is important to recognise that while water-based heat sources can only supply water-based heat users, steam-based heat sources will be able to supply both steam- and water-based heat users. In cases where steam-based heat sources are supplying water-based users, the heat link can also be expected to be water-based. For this reason, steam-based waste heat sources seeking an exemption under Article 14(5)(c) will need to be assessed against the threshold criteria for both water- and steam-based heat links.

In performing the exercise it is apparent that size of the user relative to the heat source is not critical to the economic viability of the scheme as the heat link is sized according to the demand presented by the heat user[8]. Instead, the principal criteria for establishing whether a user is suitable would be the size of the user and its proximity to the heat source. As such, linking a small heat user to a large heat source can be economically viable as long as the user is sufficiently close to the heat source.

The need to consider both user size and position relative to the heat source make it challenging to develop criteria that can be clearly communicated to parties seeking an exemption and effectively applied by the Regulator. However, one possible approach would be to use a graphical method whereby parties are required to plot possible heat users/sources on the basis of size (y-axis) against distance (x-axis) relative to the corresponding source/user, this plot could then be overlaid with a line representing the limit of economic viability such that any points sitting above this line would be considered to be suitable for linking. Conversely, if all points identified were found to sit below this line it would be clear that no users would be suitable and an exemption from the requirement to conduct a full CBA would be appropriate. This approach is presented below in Figure 9.

Figure 9 Proposed Graphical Method for Identifying “Suitable” Heat Users



The limit line will vary dependent upon the heat transfer medium and Figure 10 presents the limit lines derived from the CBA analyses performed for steam- and water-based links.

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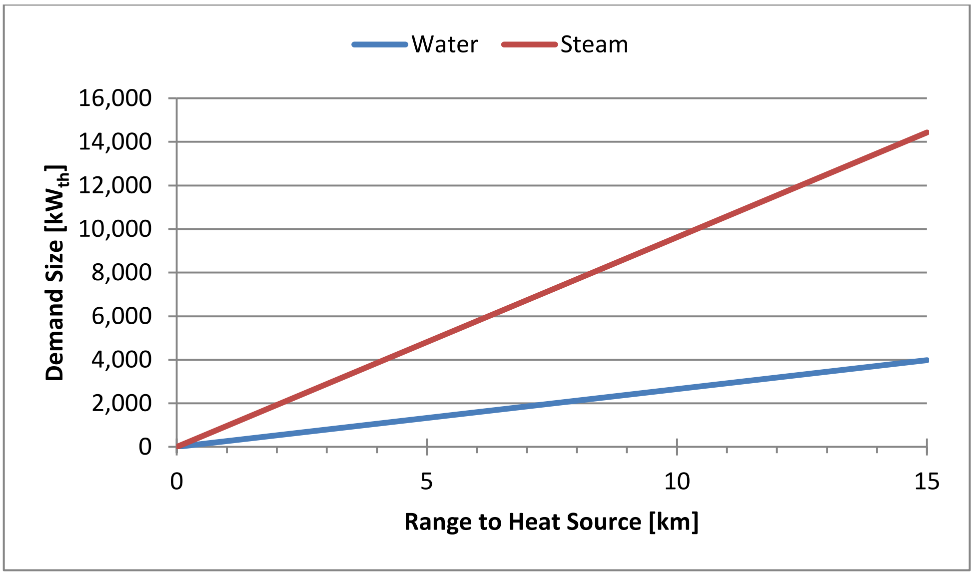
[8] In the DCF analysis it has been assumed that the modification costs would be mostly associated with the installation of heat recovery equipment (e.g. heat exchangers) and circulation pumps, which are modular in nature and so can be scaled to match the heat demand presented by the heat user. However, it is possible that some processes may entail works requiring the modification/replacement of major plant items so that the costs of modification would be dictated by the size of the heat source. In such cases the size of the heat user relative to the heat source would be of greater importance. However, as such considerations would be highly process-specific they would be best taken into consideration through a full cost benefit analysis.

Figure 10 Economic Viability Limit Lines for Water and Steam-based Heat Linking Projects



6 Closing Remarks

The analysis performed seeks to establish a justifiable framework for exempting installations from the need to perform a cost-benefit analysis under Article 14(5) and (d) of the Energy Efficiency Directive. Modelling has been performed considering the 'best case scenario' such that the thresholds values set represent the limit of economic viability under the most favourable conditions. This is to ensure that installations are only exempted from the requirement to perform a cost-benefit analysis where the supply of heat is highly unlikely to be economically viable.