Efficient district heating and cooling: does it promote the 2050 decarbonisation goals?

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Keywords

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Abstract

This work aims to provide a new definition of efficient district heating and cooling that better aligns with the decarbonisation goals set for the energy system by 2050. To do so, it elaborates on the current definition provided in the Energy Efficiency and Renewable Energy Directives. Through the interpretation and discussion of the limitations of the current definition, the final goal is to help policy makers understand the provisions required to set effective energy policies for district heating and cooling. Only by doing that can the framework needed to monitor its effective evolution towards the decarbonisation of the energy sector in Europe be established.

With this goal, we, first, provide our interpretation of the current definition of efficient district heating and cooling. We continue identifying areas that can be improved in future legislative acts without changing the scope of the current definition. These areas include the requirements for the harmonisation of the energy vectors to be accounted, the role of cogeneration and thermal losses, and the combination of thresholds required to comply with the current definition. In addition, we thoroughly review the role of cogenerated heat in the framework of district heating and cooling. This includes the use of fuels, the associated efficiencies and CO_2 emissions, and ultimately the right criteria to assess those.

Our analysis shows that a definition based only on energy efficiencies and combination of input fuels is not enough to ensure low-carbon district heating and cooling. Therefore, a new definition based on the carbon intensity together with a carbon threshold that decreases over time should be included in the coming EU legislation. Under this approach, we conclude that the existing definition with some additional provision may only be valid until 2030 and that fossil-fuelled CHP cannot fit in efficient district heating and cooling, even if highly efficient. After 2030, more restrictive CO_2 requirements have to be in place.

Introduction

The district heating and cooling (DHC) sector is one of the main targets for energy efficiency of the European energy policy (European Commission, 2016). There are several reasons to that. First, it allows the utilisation of available energy sources at large scale connecting them with consumption sites (typically urban areas) and benefiting from economies of scale. Moreover, DHC enables the use of thermal storage that provides flexibility not only to the heat supply but also to the power sector within the coupling of the heat and power sectors.

The deployment of the district heating sector is uneven across Europe, large deployment in Northern countries and limited in Southern ones. On average, it represents 7 % of the total heat supply in Europe (Eurostat, 2019). However, the sector is expected to undergo significant changes as the energy sector evolves to achieve goals set in 2050 (Mathiesen et al., 2019). Policies should support the expansion of the sector where techno-economic opportunities are identified and its transformation towards decarbonisation – in line with global energy targets.

Today, the concepts of 'district heating' or 'district cooling' (DHC) – distribution of thermal energy in the form of steam, hot water or chilled liquids, from a central or decentralised source of production through a network to multiple buildings or sites, for the use of space or process heating or cooling. (Article 2(19) of the RED II (2018/2001)) (European Council, 2018) – are present in the two main directives defining the European energy policy (European Commission, 2012; European Council, 2018).

In addition and even more importantly, these two directives introduce the concept of efficient district heating and cooling (EDHC) – a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat – as defined first in Article 2(41) of the EED (European Commission, 2012).

EDHC, under its current definition, aims to promote the deployment of cleaner energy sources building upon the opportunities that thermal networks offer concerning the utilisation of energy sources that can best be harnessed and distributed via centralised systems, such as waste heat. Accordingly, the current EDHC definition aims to promote three types of sources: renewables, waste heat and cogenerated heat by setting a minimum threshold for each of them. Thus, if a thermal network uses 50 % renewable energy or more is considered as an EDHC. The same applies for waste heat while for cogenerated heat the threshold goes up to 75 %.

To make things clearer, in Figure 1, we create a graphical representation of the concept of EDHC in the form a ternary plot. A ternary plot shows corresponding values for a portfolio or mixture of 3 elements in the form of an area. In our case, these three elements correspond to fossil-fuelled CHP, RES & waste heat, and fossil fuels. The three vertexes represent the following: the top is 100 % CHP, the bottom right 100 % RES and the bottom left 100 % natural gas. Each point in the plot corresponds to a unique combination of the three. For each point in the triangle shares should be read in the following way: CHP, horizontal lines with the scale on the left side, fossil fuels, diagonal lines from left to bottom with the scale at the bottom of the triangle and RES and waste heat, diagonal lines from right to bottom with the scale at the right side. So, if we pick a point to represent an EDHC network it has to fall within the green area. Such a point, for example, at the centre of the triangle is fuelled by 34 % CHP, 33 % RES and waste heat and 33 % fossil fuels. This point complies under the '50 % of a combination of such energy and heat' option set in the definition.

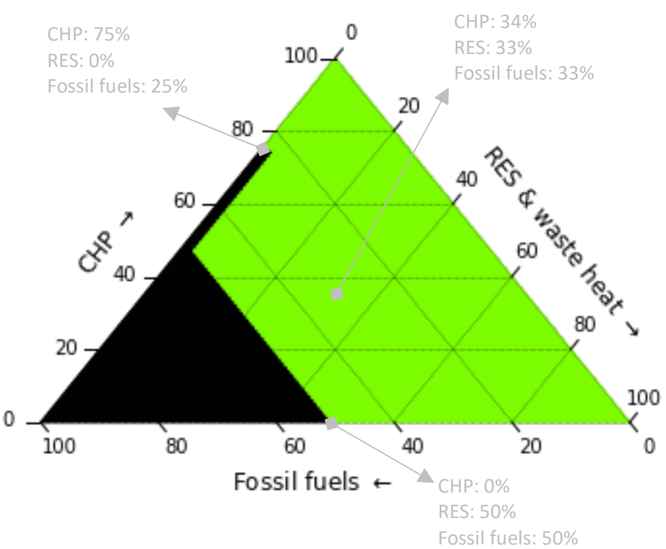

Figure 1. Interpretation of the definition in the form of a ternary plot. Green area shows the combinations that fall under the definition of efficient district heating and cooling.

However, there are aspects that can be subject to interpretation. For example, what does 'using at least' exactly mean: Is 49 % fossil-based cogenerated heat combined with only 1 % renewable energy acceptable, with the remaining 50 % using heat only fossil fuelled boilers, such as coal, oil or natural gas? Additional questions are: where in the energy supply chain should these shares be counted? Is it useful energy that the consumer effectively uses? Is it energy delivered to the consumer? Is it energy produced or introduced in the network or the energy content of the input fuels?

Not only do practical questions on the current definition have to be resolved but also fundamental ones regarding the effectiveness of the definition in achieving the decarbonisation goals for the energy system have to be discussed as well. In this work, we aim to address all these questions and provide a more robust definition.

Interpretation and areas of improvement of the current definition efficient district heating and cooling definition

The current definition of efficient district heating and cooling systems raises some issues that have to be further discussed to clearly determine what an efficient district heating and cooling system is. Four specific aspects are tackled in this work:

- the accounting of the different energy sources along the energy value chain,
- the requirements for the cogenerated heat,
- the role of thermal losses in the definition,
- the adequacy of the combination of thresholds to ensure clean district heating and cooling systems.

In our view, the definition of EDHC should contribute to increase, on the one hand, the energy efficiency of the DHC networks and, on the other, the use of renewable energy sources in district heating and cooling.

While the promotion of renewable sources is clearly sought, by setting specific thresholds for renewables and waste heat or by missing references to thermal losses or to technology options, the promotion of its efficiency is less evident. In other words, seeking for cleaner options does not necessarily imply better efficiencies and vice versa. In fact, the three first elements listed before, which we deem needed to provide a better definition of EDHC, tie directly with efficiency aspects. The last one, on the combination of thresholds, implies both dimensions and needs further analysis.

As a result, the definition of EDHC requires the alignment of both goals: energy efficiency and renewable shares. This is underlined by the fact that the definition is part of both the energy efficiency and the renewable energy directives. Next, we discuss in detail these four aspects.

FINAL (FE), GROSS FINAL (GFE) OR PRIMARY ENERGY (PE)

The current definition of EDHC accounts energy flows, instead of installed capacities per type of technology, to determine if a local network is efficient or not. This means that it focuses on the operation rather than on the design of the thermal network. In our view this is the right approach, however it comes with the additional effort of periodic evaluations, typically on annual basis, of the operation of the network. Still, from the point of view of Member States (MSs), this follows the normal data collection cycles of national statistics.

Thus, focusing on energy flows, the current EDHC definition refers to 'energy' and 'heat'. The use of both terms can be misleading at first instance. 'Energy' can refer to the energy content of the input fuels or the heat already produced whereas the term 'heat' can only refer to the latter.

There are some aspects that make the need of accounting in 'heat' (or 'cold') terms clear, which means in any energy flow (final or gross-final energy) except for primary energy.

First, the use of waste heat sources can only be accounted as thermal energy since it is a sub-product of an external process. This means that the input fuel for such external process cannot be allocated into the district heating and cooling system. Put differently, the energy required to produce waste heat is zero.

Second, if the accounting was done in primary energy terms, heat generation technologies powered by secondary fuels (i.e. power-to-heat technologies) would need a further breakdown of the fuel mix (natural gas, biofuels or others) required to produce those secondary fuels (i.e. electricity, hydrogen or biofuels). Although possible, this allocation requires additional efforts to characterise a larger amount of transformations in the national energy systems. Not only that but in the case of CHP, accounting in primary energy terms leads to different approaches and multiple interpretations. The allocation of the input fuel into the two outputs (heat and power) can follow various approaches (i.e. proportional, exergetic or the finish allocations (Esser and Sensfuss, 2016)) that lead to different heat accountings. As a result, for those secondary fuel-to-heat technologies the approach of either gross final or final energy terms is more suitable. Put differently, for the sake of simplicity and harmonisation between MSs, we should only look into the heat generated (gross-final energy) or the heat provided to end users (final energy).

Third, it is more intuitive to account ambient heat from heat pumps under the 'heat' approach. As for the case of waste heat, ambient heat is a thermal quantity directly incorporated from the environment, without any conversion. Even though, it could be expressed in either energy or thermal terms with a conversation factor equal to one, doing it in 'heat' terms is the natural way.

It is clear, then, that to make energy flows comparable and to avoid the potential conflicts presented before, the definition has to be built on gross final energy terms as defined in Article 7(1) of the RED II. As a result, the use of both 'energy' and 'heat' terms should be better introduced in the definition to avoid confusion and misinterpretations. An easy solution would be to remove 'energy' and keep only the term 'heat' or 'cold' delivered to the network.

THERMAL LOSSES

Thermal losses are not considered in the current definition of EDHC. This is valid if we assume that all generation units supply energy at the same point in the network or if, even from different location points, losses can be assumed similar to all generation units. Under both assumptions, losses do not affect the compliance of a network as efficient. This is because the definition determines efficiency mainly by the proportions of the various heat generation sources in the overall generation mix and not by the proportion between input and output, which is the classic energy efficiency indicator. As a result, in the calculation of the different shares of losses, these cancel out. However, they have implications on the efficiency of the system in the classic sense, as defined in the EED.

From this point of view, the current definition does not directly promote the energy efficiency component in its strict sense since it disregards thermal losses but only indirectly through the requirement of having renewables, CHP and waste heat in the generation mix. The reason for this is that renewables can be assumed 100% efficient, CHP is an energy efficiency instrument to better use any input fuel and waste heat recovery is also a classic energy efficiency instrument to ensure that, from a give energy input, the usable output is maximised. Therefore the definition only addresses generation efficiency indirectly (even if it does not explicitly specify that CHP in the mix should be of high-efficiency), and it does not address losses in the distribution of heat and, as a result, does not fully incentivise the transition to more efficient thermal networks (new generation of district heating systems).

To provide a rough estimation on the importance of thermal losses, we performed an analysis using the information contained in national energy balances (Eurostat, 2019). For 2018, data show that losses in the EU, under the 'derived heat' category, have risen up to 8 %[1]. On the other hand, from the current evolution of DHC towards lower supply temperatures (4^{th} and 5^{th} generation) one can expect lower thermal losses in the future. Still, losses play a role in the efficiency of DHC, and with an energy policy being devoted to the efficiency first principle this is of higher priority for DHC as a possible instrument for heat decarbonisation and carbon neutrality under the European Green Deal (European Commission, 2019).

COGENERATED HEAT

The contribution of the cogenerated heat is the most difficult component in the definition of the EDHC because it affects both the efficient (high and non-high efficiency cogeneration) and the clean generation of heat (fossil- and non-fossil-fuelled cogeneration). Under the current definition, it has implications for two modes: 75 % cogenerated heat and the combined 50 %.

Cogeneration adds an unsolved component when fuelled by renewable sources. In these cases, there is a conflict in accounting – either it can contribute to the 75 % of cogenerated heat or to the 50 % renewable energy in order to comply with the efficient district heating definition. Logically, cogenerated heat from renewable is the preferable option as the 50 % threshold is easier to reach. Therefore, the 75 % threshold remains for the fossil-fuelled cogeneration.

As defined now, there are no conditions on how this cogenerated heat can be produced. This, in principle, allows the accounting of cogenerated heat produced in non-high efficiency

1. This number should be taken as a gross estimation as, according to EUROSTAT, values on thermal losses are less certain.

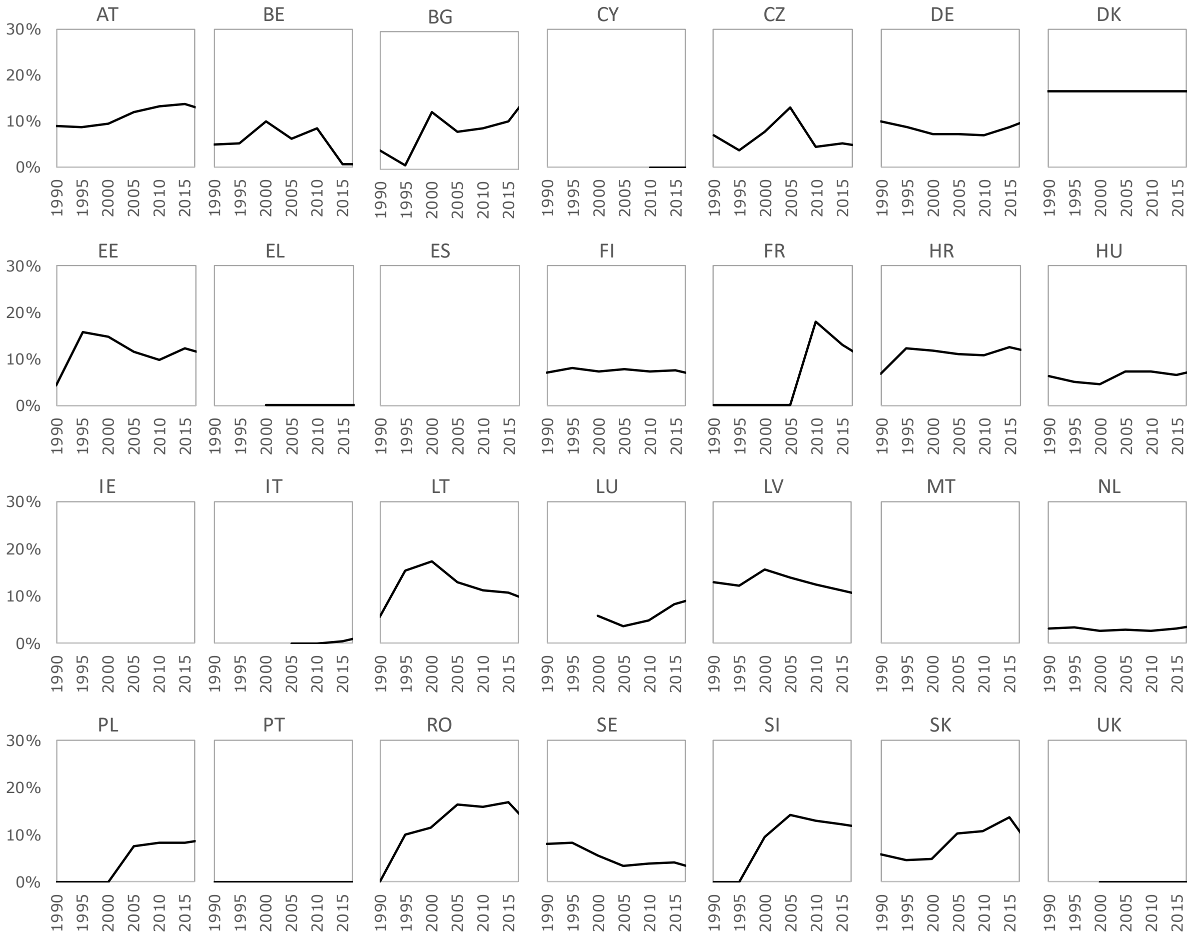

Figure 2. EU27 + UK overview on heat distribution and transmission losses as a share of the total heat supplied. 1990–2015.

CHP plants running on fossil fuels. This means that there is no requirement for the combined production of heat and power to be more efficient than their separate production. As a result, the heat produced in this way does not contribute to the increase of neither the efficiency of the system nor the increased use of renewable energy sources. Therefore, cogenerated heat requires additional criteria to be part of the future EDHC definition.

In our view, following the rationale behind the methodology for determining the efficiency of the cogeneration process presented in Annex II of the EED, fossil-fuelled cogeneration shall, at least, provide primary energy savings of at least 10 % – or at least 0 % if the capacity is lower than 50 kWe – compared with the reference savings for separate production of heat and electricity to be included in the EDHC definition.

However, the adequacy of cogenerated heat as part of EDHC after 2030 is even more complicated. As the energy system evolves towards its decarbonisation goals set by 2050, the condition on PES will not be sufficient, since it would still emit too much greenhouse gases (Figure 3).

As we said before the aim of this work is twofold: first, improving the current definition without changing its approach and, second, provide a new approach to guarantee the effectiveness of the EDHC definition in the long terms. Staying within the first, our proposal is to include a provision on highly efficient requirement for the cogenerated heat. Yet, we anticipate it will not be sufficient in the mid- to long-term.

PROPOSED CLARIFICATION OF THE DEFINITION OF EFFICIENT DISTRICT HEATING AND COOLING FOR THE TIME PERIOD UNTIL 2030

In summary, the current definition of EDHC clearly states the need of accounting energy flows over a given period (typically a year) and not available capacities. However, it does not clearly state whether the accounting is on GFE (gross final energy) or PE (primary energy) terms. Moreover, it does not consider energy losses and it allows any kind of cogenerated heat. This means, for example, that a district heating system designed with a net heat capacity share of 60 % renewable and 40 % fossil fuel based does not qualify as efficient if more than 50 % of the heat produced over a year comes from its fossil capacity. Given the above, our proposal a transition definition of EDHC until 2030 reads as follows: 'Efficient district heating and cooling', as defined first in Article 2(41) of the EED, means a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % of **high-efficiency** cogenerated heat or 50 % of a combination of such **thermal energy supplied to the network**.

Following this short-term definition, we provide some simplified examples of EDHC. Each of the examples represent one of the four alternatives set out under the current definition of EDHC. These are:

- 75 % Cogeneration. Figure 4.a shows a system providing 76 % of the gross heat from CHP and the remaining from a gas boiler.

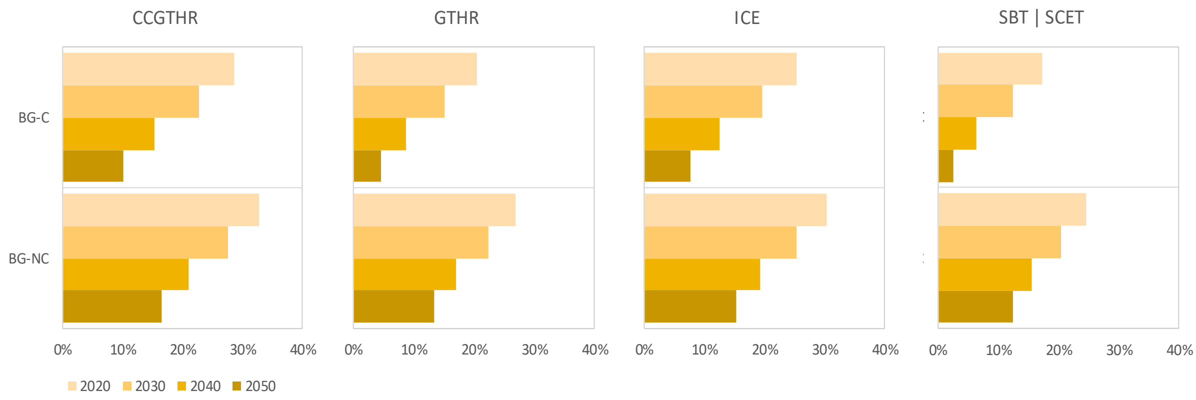

Figure 3. Primary energy saving for several CHP technologies (CCGTHR: Combined Cycle Gas Turbine with Heat Recovery, GTHR: Gas Turbine with Heat Recovery, ICE: Internal Combustion Engine, SBT/SCET: Steam Back Pressure Turbine/ Steam Condensing Extraction Turbine) in comparison with heat supply options: BG-C: gas boiler condensing, BG-NC: gas boiler non-condensing. Note: global efficiency: 90 %, power-to-heat ratios as defined in the Directive 2012/27/EU. Reference efficiencies from (Mantzos et al., 2019).

- 50 % Waste. Figure 4.b depicts a system providing 50 % of the gross heat from a generic waste heat source and the remaining 50 % from a gas boiler.
- 50 % Renewables. Figure 4.c presents a system based on a single boiler that provides half of the gross heat from the combustion of biogas.
- 50 % Combination. Figure 4.d shows a system including a dual boiler, two heat pumps, a CHP unit and a waste heat source. The combination of heat produced from the different clean sources sum up to 50 % of the total.

From the above provisional definition, it is evident that issues such as the cogenerated heat from fossil fuels are not resolved. Our point, so far, is that even the provision on high-efficiency performance for such cogenerated heat may not be sufficient in future decarbonised energy systems. Thermal losses is another aspect that remains unsolved. DHC showing large thermal losses may not be a sustainable enough solution even if it complies with the requirements of EDHC as defined today, especially in the context of the future energy system. All these aspects open the door to exploring new approaches in the definition of EDHC.

A new definition of efficient district heating and cooling in a future context

We aim to improve the current definition and propose a new one based on quantifiable sustainability criteria that can be easily updated in the future. To do so, we translate the current shares of input fuels (and technologies) into associated CO_2 emissions, discuss what should be the maximum CO_2 emission thresholds for different scenarios and, then, translate those thresholds back into new shares of input fuels, leading to an updated definition.

By doing so, we anticipate that the current definition based on shares of technologies is in a good direction to promote clean and efficient energy sources in the short term. However, some additional improvements are required in the mid- to long-term.

To begin with, in Figure 5 we recall the ternary plot (presented earlier) indicating the area (green) that complies with the current definition of efficient district heating and cooling. One problem that we already noted is that it includes some cases where there is inconsistency between the third and fourth clause of the definition that causes lower CHP shares to qualify for the definition as long as it is accompanied by a small fraction of Renewables. For example, 1 % Renewables and 50 % CHP qualifies as efficient DH under the last clause of the definition "50 % combination of above" but not under the third clause "more than 75 % cogeneration". This corresponds to the green area to the left of the dotted line (see Figure 5). To our view, the dotted line corresponds better to the implied boundary in the current EDHC definition. Adding such line avoids the 1 % Renewables + 50 % CHP inconsistency.

This dotted line is both a straightforward and short-term solution. However, it cannot be formulated in a simple way that is understood and identified. In other words, the dotted lines requires a mathematical expression as a function of the three input variables. For this reason and the need of a consistent definition in the long term, we will try to identify a dynamic boundary that evolves over time and adjust to the decarbonisation pace of the energy system. To do so, we translate energy shares into CO_2 emissions.

First, we map the emission factors of all possible combinations for the technology families considered. We did that based on the following assumptions:

- Waste heat and renewables are treated as the same category with an emission intensity of zero. This category also includes renewable fired cogeneration and ambient heat. This assumption may underestimate the impact on the CO_2-emissions performance of renewable fuels such as biomass or other biofuels that shows CO_2-emission factors higher than zero.
- Cogenerated heat is considered to be low temperature and evaluated based on the exergetic allocation method (see Annex IV as proposed in RED II Annex VI(6)). This implies that most of the emissions will be allocated to electricity due to its higher exergy/value/quality.
- Gas fired solutions are considered for both cogeneration and fossil fuelled solution as one of the cleanest mainstream

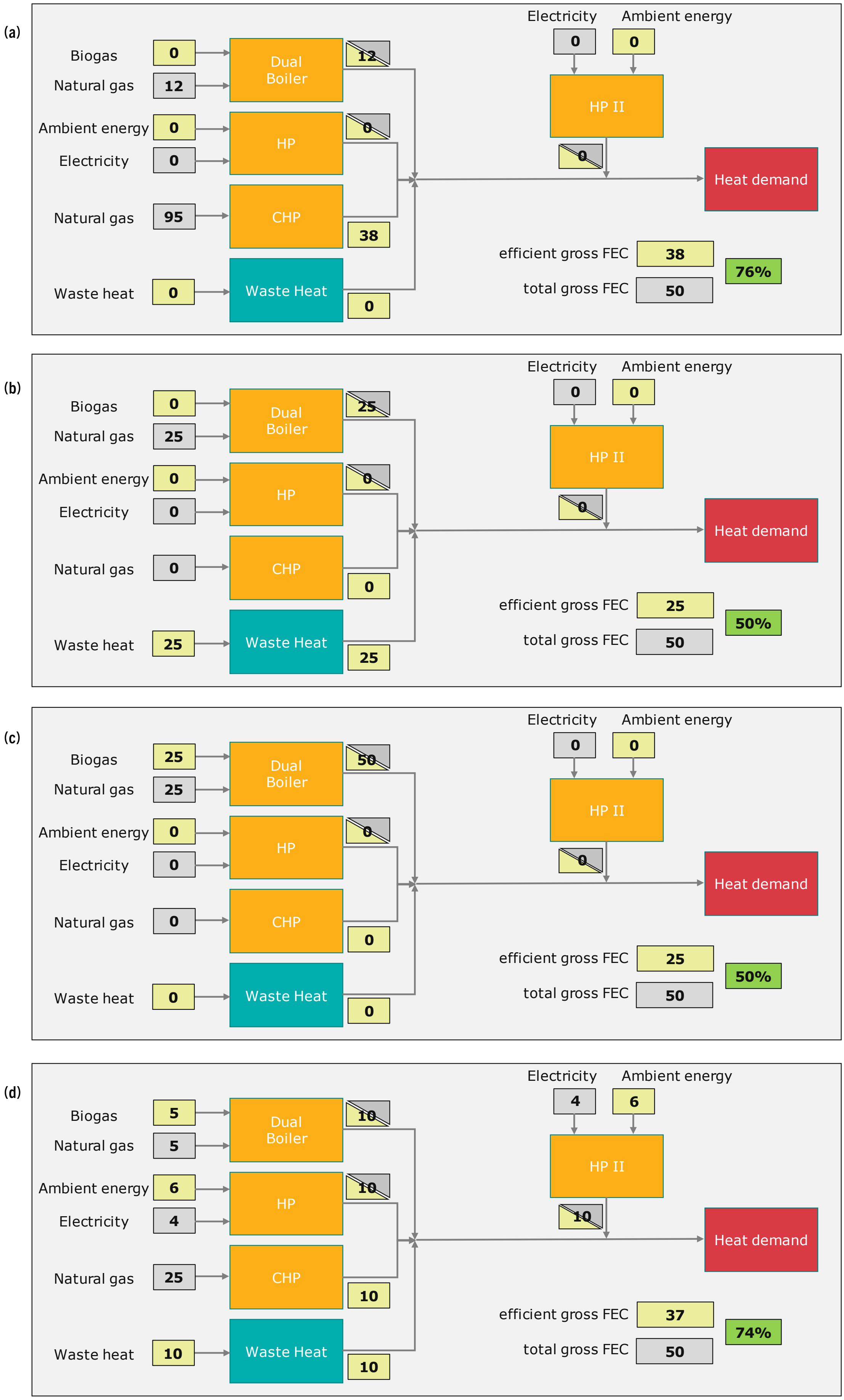

Figure 4. Mock examples of efficient district heating and cooling under the different alternatives (a) 75 % cogeneration, (b) 50 % renewables, (c) 50 % waste heat and (d) 50 % combination.

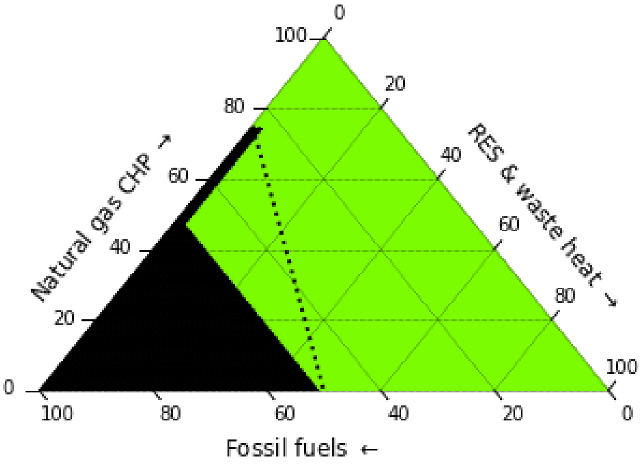

Figure 5. Current definition (green area) and implied boundary (dotted line).

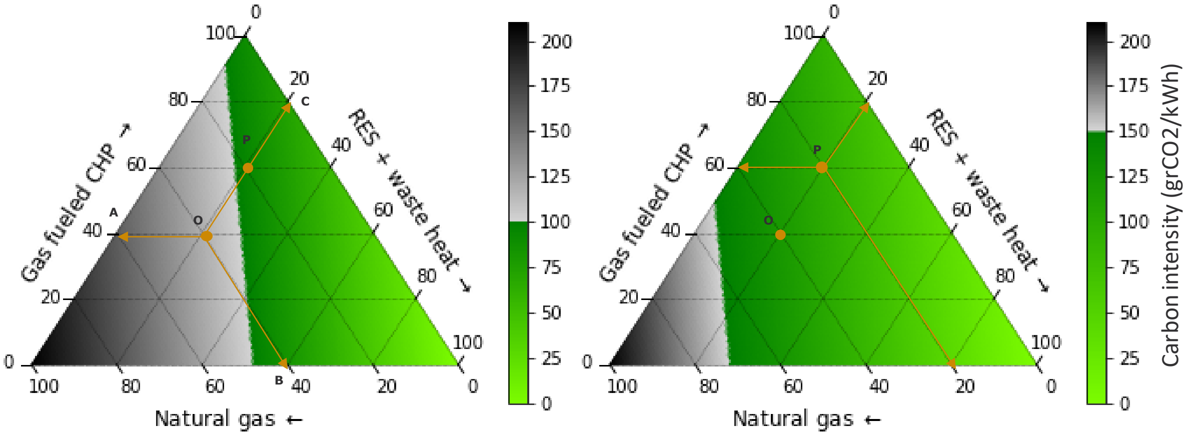

Figure 6. Evaluation of the clean (green) areas for different combination of energy sources shares in district heating and cooling systems. Two CO_2 thresholds are considered: 100 $grCO_2$/kWh (left) and 150 $grCO_2$/kWh (right).

non-renewable fuels. Coal based solutions would not qualify in the new definition.

- The emission factors are defined per unit of gross-final energy (thermal losses are neglected).

Next, we discuss the implications on the shares of technologies by setting different carbon intensity thresholds. The selection of one specific carbon intensity threshold determines all the possible combinations that lead to lower emissions (green area). The more stringent the threshold the smaller the area. Following this approach, a district heating and cooling system falling in the green area will qualify as a 'clean' one.

As a result, in Figure 6, we present the CO_2 intensity of all possible technology combinations and the implied boundary for two different carbon intensity thresholds: 100 (left) and 150 (right) $grCO_2$/kWh. These thresholds are chosen based on the current definition of EDHC that stands in between. To construct the ternary plots we have assumed the following emission factors: for fossil fuels a factor of 220 $grCO_2$/kWh and for CHP a factor of 90 $grCO_2$/kWh following an exergetic allocation with a heat supply temperature of 60 °C. As indicated above, the emission factor of renewables and waste heat is assumed to be 0 $grCO_2$/kWh.

In Figure 6 we provide a system 'O' that combines 40 % of Natural gas CHP, 20 % of renewables and 40 % of fossil fuels. This combination leads to a CO_2 emission factor of 124 $grCO_2$/kWh. This system 'O', therefore, would comply with the 150 $grCO_2$/kWh threshold (Figure 6 right) but not with the 100 $grCO_2$/kWh one (Figure 6 left). Another system 'P' combining 60 % of gross heat from gas-fuelled CHP, 20 % from RES + waste heat and 20 % from fossil fuels provides an CO_2 emission factor of 98 $grCO_2$/kWh, thus complying with both thresholds.

We mentioned before that the current definition is in a good direction to promote clean and efficient energy sources. If we compare the green area in Figure 6 (left) with the area to the left of the dotted line in Figure 5, they turn out to be relatively similar. This means that the current definition, if we exclude the green area to the left of the dotted line in Figure 6, is promoting solutions that perform in the order of 100 $grCO_2$/kWh or below.

Now that we know the order of magnitude of the current definition in terms of CO_2 emissions, we should look into two future milestones for the energy policy trend, 2030 and 2050. The EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions. However, this does not mean that all technologies used will be at zero emissions, some will be more and some less. Clean DHC should be supporting these goals. That is, in the end, why we are coming up with a new definition for EDHC.

By 2030, we propose a 'Efficient/clean' district heating and cooling definition having in mind a threshold of the order of 100 grCO_2/kWh. These value is taken as reference according to the taxonomy technical report that puts the threshold of 100 grCO_2eq/kWh for heat (and electricity production) (EU Technical Expert Group on Sustainable Finance, 2019).

A definition that respects that criterion can be formulated as follows: "A district heating or cooling system of which at least half of the heat or cold is supplied by zero carbon sources".

To make it more clear and specific, this condition is graphically represented in Figure 7. As it can be observed, our proposal (green area) is slightly more restrictive than the 100 grCO_2/kWh isoline (dotted line). The reason for that is setting the vertical line as boundary we simplify the wording of the new definition which also makes it easier to understand. Otherwise, analytical equations would be required. Given the assumptions

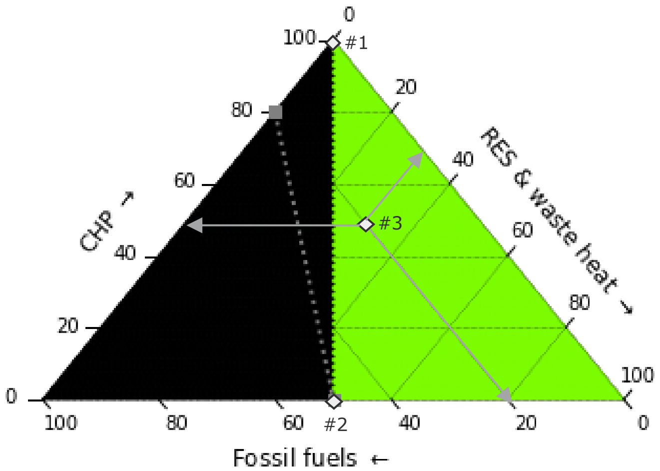

Figure 7. Proposed definition of efficient/clean district heating and cooling by 2030. CO_2 threshold of 100 gCO_2/kWh.

above this line corresponds to combinations that have an emission intensity ranging between 95–105 grCO_2/kWh. This is a good approach starting from the current EDHC definition.

Examples under which qualify under this definition (valid until 2030) are the following:

- Example 1 (dot #1 in Figure 7): 0 % RES+WH, 0 % Fossil fuelled (non-CHP), 100 % CHP
- Example 2 (dot #2 in Figure 7): 50 % RES+WH, 50 % Fossil fuelled (non-CHP), 0 % CHP
- Example 3 (dot #3 in Figure 7): 30 % RES+WH, 20 % Fossil fuelled (non-CHP), 50 % CHP

Biomass fuelled CHP would count as renewable, so for example a 50 % biomass CHP and 50 natural gas would also qualify.

After 2030, this threshold can be revised every five years. This signifies a decrease of 16.67 grCO_2/kWh for every 5-year period, and eventually reaches 0 grCO_2/kWh in 2050. Naturally, following this threshold decrease biomass will be excluded from the definition of EDHC at some point. This does not exclude biomass from being used in regular DHC, though. It could also be used together with CCS and still qualify.

By 2050, when associated emission should tend to zero (2050 Zero carbon targets) we can introduce also a new concept called 'Clean district heating and cooling', which means a district heating or cooling system using exclusively a combination of renewable fuelled (either individual or combined generation) heat, including ambient heat, and waste heat sources. For the period 2030 to 2050, the fossil fuel contribution will decline by 16.67 % every 5 years following the direction of the taxonomy for sustainable financing [8]. In line with this, by 2040 district heating and cooling will qualify as efficient if the share of thermal energy from renewables is 60 percentage points higher than the one from fossil fuels. This condition will keep the emission factor below 50 grCO_2/kWh.

PROPOSAL FOR NEW DEFINITIONS

By 2030, 'Low carbon district heating and cooling', means a district heating or cooling system using always **equal or more** renewable energy technologies than fossil fuelled individual generation energy technologies.

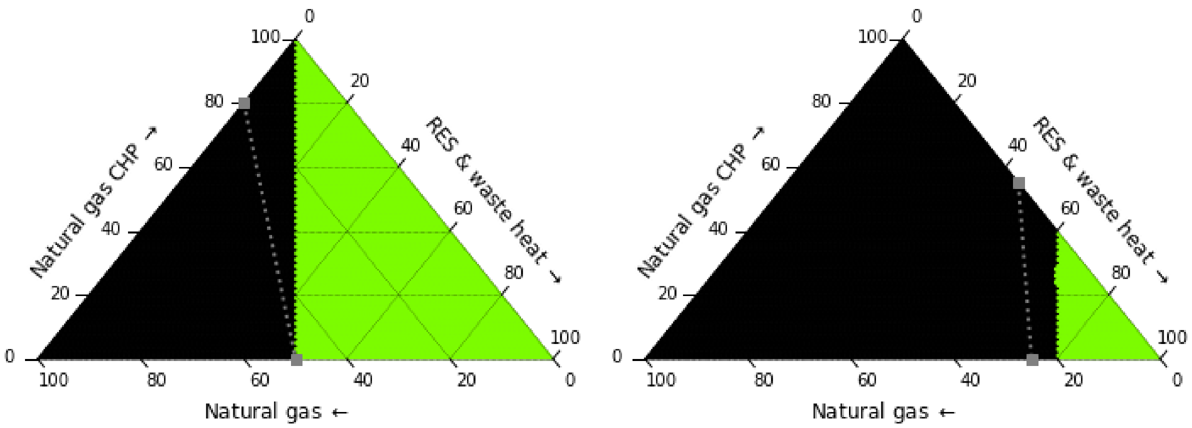

Figure 8. Evolution of the proposed definition (left) by 2030 (right) and by 2040 (right) to reach the zero-emission district heating by 2050.

By 2040, 'Clean district heating and cooling', means a district heating or cooling system using **always 60 percentage points** more renewable than fossil fuels fuelled individual generation energy technologies.

By 2050, 'Zero carbon district heating and cooling', means a district heating or cooling system using **exclusively** a combination of renewable fuelled (either individual or combined generation) heat, including ambient heat, and waste heat sources.

Conclusions and policy recommendations

The aim of this work was, first, to elaborate on the definition of efficient district heating and cooling – as defined in Article 2(41) of EED and Article 2(20) of RED II. And second, to provide a new approach for the definition valid in future decarbonised energy systems.

As we presented, currently, 'Efficient district heating and cooling', as defined first in Article 2(41) of the EED, means a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % of cogenerated heat or 50 % of a combination of such energy and heat'

However, there are elements that can be subject to interpretation. Based on our interpretation, the current definition of EDHC clearly states the need of accounting energy flows over a given period (typically a year) and not available capacities. However, it does not explicitly define whether the accounting is on gross final energy or primary energy terms – gross-final energy has to be considered as defined in Article 7(1) of the RED II. Moreover, it does not consider energy losses and it allows any kind of cogenerated heat, either highly efficient or not. This means, for example, that a district heating system designed with a net heat capacity share of 60 % renewable and 40 % fossil fuel based does not qualify as efficient if more than 50 % of the heat produced over a year comes from its fossil capacity.

Following this discussion, we came up with a proposal on how to make the current definition of efficient district heating and cooling more effective and understandable while tackling the four elements presented above. This proposed definition, however, does not solve potential issues concerning thermal losses or combination or thresholds.

PROPOSED MODIFICATION OF THE CURRENT DEFINITION OF EFFICIENT DISTRICT HEATING AND COOLING

'Efficient district heating and cooling', as defined first in Article 2(41) of the EED, means a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % of highly-efficient cogenerated heat or 50 % of a combination of such thermal energy going into the network'.

Even though the current definition of efficient district heating and cooling aims to promote cleaner and more efficient district heating and cooling in Europe, its scope may not be sufficient given that the EU has a net-zero emission target by 2050. The two dimensions – clean and efficient – do not necessarily come together unless additional provisions are included in the current definition. Along this line, in section 4, we worked towards analysing the definition and its provisions taking into account the evolving energy system towards its decarbonisation goals by 2050.

Following, the CO_2 evaluation criteria, we provided three updated definitions to be applied for different time frames. By 2030, we suggest a definition that ensures carbon intensities below 100 gCO_2/kWh, while, by 2040, the share of renewables should be 60 percentage points more than fossil fuels to guarantee emission factors of the order of 50 gCO_2/kWh. Last, by 2050, district heating and cooling system should become zero-emissions and, thus, becoming a clean district heating and cooling.

References

Esser, A., Sensfuss, F., 2016. Review of the default primary energy factor (PEF) reflecting the estimated average EU generation efficiency referred to in Annex IV of Directive 2012/27/EU and possible extension of the approach to other energy carriers. Final Rep. – Eval. Prim. energy factor Calc. options Electr.

EU Technical Expert Group on Sustainable Finance, 2019. Taxonomy Technical Report June, 414.

European Commission, 2019. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. The European Green Deal. COM(2019) 640 final [WWW Document]. https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

European Commission, 2016. An EU Strategy on Heating and Cooling. COM(2016) 51 final. https://doi.org/10.1017/CBO9781107415324.004

European Commission, 2012. DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Off. J. Eur. Union 1–56.

European Council, 2018. DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Off. J. Eur. Union 2018.

Eurostat, 2019. Energy balance flow for European Union (28 countries) 2017 [WWW Document]. 2019. https://ec.europa.eu/eurostat/web/products-datasets/-/nrg_sankey (accessed 7.20.19).

Mantzos, L., Wiesenthal, T., Neuwahl, F., Rózsai, M., 2019. The POTEnCIA. Central Scenario. An EU energy outlook to 2050, JRC Science for Policy Report. https://doi.org/10.2760/78212

Mathiesen, B.V., Bertelsen, N., Schneider, N.C.A., García, L.S., Paardekooper, S., Thellufsen, J.Z., Djørup, S.R., 2019. Towards a decarbonised heating and cooling sector in Europe Unlocking the potential of energy efficiency and district energy.