# Potential for district heating/cooling and cogeneration in Europe: An analysis of EU Member States' assessments under EED art. 14

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## Abstract

This paper analyses the comprehensive assessment reports on the national potential of high-efficient cogeneration (CHP) and efficient district heating (DH), submitted by the EU Member States to comply with Art 14 of the Energy Efficiency Directive. In total 26 reports from 24 Member States are analysed. The analysis focuses on following elements: (1) the reported forecasted evolution of the heating and cooling demand; (2) mapping of heating and cooling demand and potential supply points; (3) the results of the technical and economic potential studies for CHP and DH; and (4) the reported policies and measures to realize this potential

While extensive guidelines were given by the European Commission and the JRC, the Member States applied different calculation methods and input parameters and presented the results in different ways. Different interpretations on how to calculate the technical potential could be observed as well. In addition, several Member States failed to report all required data to the European Commission. It is, as a result, very challenging to compare the results of the comprehensive assessment reports. As a recommendation, a reporting template and a set of mandatory indicators could be integrated in a future comprehensive assessment.

Several Member States reported a high additional economic potential for district heating networks. The additional potential of cogeneration was more limited and often correlated with the potential for district heating. The nation-wide estimates of the energy savings by district heating/cooling and cogeneration of the different Member States could not be compared.

A wide range in quality of heat maps indicating demand areas and supply points could be observed as well. Some Member States have developed sophisticated interactive geographical analysis tools. While this might herald an era in which such tools become standard analysis tools, efforts are needed for a better spread of such tools amongst all EU Member States.

## Introduction

"Heating and cooling consume half of the EU's energy and much of it is wasted." With this very first sentence in its Strategy on Heating and Cooling (EC, 2016), the European Commission has summarized very well both the importance of heating and cooling for the economy of the Union and the challenges to make this energy sector more sustainable. The European Commission makes an appeal with this strategy to "integrate efficient heating and cooling into EU energy policies" and calls for action "on stopping the energy leakage from buildings, maximising the efficiency and sustainability of heating and cooling systems, supporting efficiency in industry and reaping the benefits of integrating heating and cooling into the electricity system." The strategy continues by focusing on three components of the energy system: district heating and cooling (DHC), cogeneration of heat and power (CHP) and smart buildings.

The first two components – district heating and cooling and cogeneration – are the subject of Art 14 of the Energy Efficiency Directive (EED; Directive 2012/27/EU), the European Commission's tool to promote efficiency in heating and cooling. As a motivation for the inclusion of the article, the EED states that:

"High-efficiency cogeneration and district heating and cooling has significant potential for saving primary energy, which is largely untapped in the Union." (Preamble of the EED (35)) The EU Strategy on Heating and Cooling confirms this potential by highlighting the advantages of DHC and CHP:

- "District heating can integrate renewable electricity (through heat pumps), geothermal and solar thermal energy, waste heat and municipal waste. It can offer flexibility to the energy system by cheaply storing thermal energy, for instance in hot water tanks or underground."
- "CHP can produce significant energy and $CO_2$ savings compared with separate generation of heat and power. […] The economic potential of cogeneration is not being exploited."

In order to tap this potential, EED Art 14 requests the EU Member States to carry out a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling. This comprehensive assessment includes a cost-benefit analysis (CBA) covering their territory based on climate conditions, economic feasibility and technical suitability aiming at identifying the most resource-and cost-efficient solutions to meeting heating and cooling needs. The EED lists the points that have to be studied in the cost-benefit analysis:

- Description of the heating and cooling demand
- A forecast how this demand will change in the next 10 years
- A map with the geographical distribution of heating demand/generation
- The potential of high-efficiency cogeneration and district heating/cooling to satisfy the demand
- An estimate of the primary energy to be saved

The Member States subsequently must adopt policies to tap the identified potential and to take measures to support the development of efficient DHC and high-efficient CHP and the use of heating and cooling from waste heat and renewable energy sources.

To support the Member States with the implementation of Article 14 of the EED, the Commission published a document with guidelines (EC, 2013). This clarifies the methodology for the Member States to perform the cost-benefit assessment by recommending following procedure:

1. Establish the heating and cooling demand of the country
2. Prepare a forecast on how this demand will evolve in the next 10 years
3. Prepare a map of the national territory that identifies at least the main supply/demand points and district heating/cooling infrastructures
4. Identify the elements of the heat demand that *technically* could be satisfied with efficient cogeneration and district heating/cooling.
5. Identify the elements of the heat demand that *economically* could be satisfied with efficient cogeneration and district heating/cooling.
6. The resulting strategies, policies and measures based on the resulting economic potential

In addition, a document with a more detailed and practical approach and best practices was provided by the Joint Research Centre (Jakubcionis at al., 2015). It specifies how to construct baseline and alternative scenarios, the financial and social discount rates for the calculation of the net present value, which heating technologies should be considered etc.

The deadline for submission of these comprehensive assessment reports was 31 December 2015.

The aim of this paper is to analyse the submitted comprehensive assessment reports. The objective is to verify whether Article 14 of the EED has created a momentum to integrate efficient heating and cooling in the national policies of the EU Member States. First, we will outline the methodology and identify the sources on which this analysis is based. In the following chapter, a high-level overview is presented of the following information given within the EU Member States' assessments under EED art. 14:

- Current and projected heat demand
- Methodology to map the heating/cooling demand of the region
- The potential assessment for district heating/cooling
- The potential for high-efficiency cogeneration

Finally, we give an overview of policy measures implemented in the member states and discuss the results.

## Methodology

The comprehensive assessment reports of the Member States on the national potential of cogeneration and district heating/cooling have been downloaded from the website of the European Commission[1]. The analyses and conclusions of this paper are based on the contents of these reports. Out of the 28 Member States, 25 have submitted their report. In spite of the deadline of December 2015, the assessments of Croatia, Portugal and Slovenia are still not available. The Bulgarian submission is only available in the national language and is hence not included in this analysis either. Belgium on the other hand has supplied three different reports for their competent regions: the Brussels Capital Region, Flanders and Wallonia. In total 26 reports were analyzed.

The analysis focuses on following elements from the comprehensive assessment reports:

- The reported forecasted evolution of the heating and cooling demand
- Mapping of heating and cooling demand and potential supply points
- The results of the technical and economic potential studies for high-efficient CHP and efficient DH
- The reported policies and measures to realize this potential

1. http://ec.europa.eu/energy/en/topics/energy-efficiency/cogeneration-heat-and-power

**Table 1. Ratio of the estimated future heating/cooling demand of the Member States to the current heating/cooling demand, and the corresponding time horizon.**

| Member State | Short | Future/current heating/ cooling demand (%) | Time horizon |
|---|---|---|---|
| Austria | AT | 90 | 2025 |
| Belgium Brussels | BE – Bru | 96 | 2030 |
| Belgium Flanders | BE – Fla | 110 | 2035 |
| Belgium Wallonnia | BE – Wal | 98 | 2030 |
| Cyprus | CY | 0 | yearly → 2050 |
| Czech Rep | CZ | 102 | 2025 |
| Denmark | DK | 83 | 2035 |
| Estonia | EE | 85 | 2030 |
| Finland | FI | 82 | 2025 |
| France | FR | 76 | 2030 |
| Greece | GR | 129 | 2030 |
| Latvia | LV | 94 | 2030 |
| Lithuania | LT | 82 | 2030 |
| Luxembourg | LU | 95 | 2030 |
| Malta | MT | 122 | 2030 |
| Poland | PL | 110 | 2044 |
| Romania | RO | 84 | 2030 |
| Slovakia | SK | 114 | 2025 |
| UK | UK | 89 | 2025 |

The above-mentioned elements was either explicitly requested to be included in the report by the EED, or strongly recommended in the guidelines provided by the commission and the JRC.

The findings from this analysis are described in the next chapter. It is followed by a chapter discussing the findings and drawing conclusions from it. The comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling is in these chapters is referred to as 'the comprehensive assessment'.

## Analysis of the comprehensive assessment reports

### THE BASELINE SCENARIO: ESTABLISHING THE HEATING AND COOLING DEMAND OF THE MEMBER STATES

The first task of the Member States for the comprehensive assessment is reporting the current heating and cooling demand, and making a projection of this demand for the next 10 years (or more). Only 18 of the 26 comprehensive assessments reported a specific figure for this demand evolution. For the other countries, either the projected heating/cooling demand was expressed as a function of different sets of scenarios without one single value selected, or it was not available.

Table 1 reports the time horizon used by the different Member States; a variation in selected time horizons can be observed. In principle, the timeline should be looking into the future for at least 10 years, which is why most Member States selected 2030. Poland has chosen 2044 to be consistent with its cost-benefit assessment, which uses a payback time of 30 years.

Figure 1 shows the share of the projected total heating/cooling to the current demand (usually compared to 2014 or 2015 as a base year) by the Member States. Evidently, this number is highly dependent on the population and the geographical location of the country. Usually, the projection of the total heating and cooling demand is an extrapolation of ongoing trends in previous years.

Most of the countries report a declining heat demand, due to the fact that energy efficiency in buildings is increasing. Exceptions are for instance Greece, which predicts that the current heating demand is currently low due to the economic recession, and Malta, who predicts an increase in cooling demand in the service sector (hotels etc.). In general, cooling demand is only a small fraction of the reported heating/cooling demand (1–2 % or less), or it is not registered separately. Exceptions include for instance Spain and Malta, which have a cooling demand of 13 % and even 56 %, respectively.

### MAPPING OF THE HEAT DEMAND IN THE MEMBER STATES

Heat maps have demonstrated to be a vital tool for heat planning. Denmark started already in 1979 to map the existing heating demand and heating supply method; first on municipal level, then aggregated on county level. This has resulted in a heat policy that opted for district heating in densely populated areas and natural gas in other areas and in municipal heating plans defining areas that were to be supplied either by district heating or natural gas (DEA, 2015).

Following the Danish example, the EED requires the EU Member States to provide a map of the national territory identifying heating and cooling demand points, existing and planned district heating and cooling infrastructure and poten-

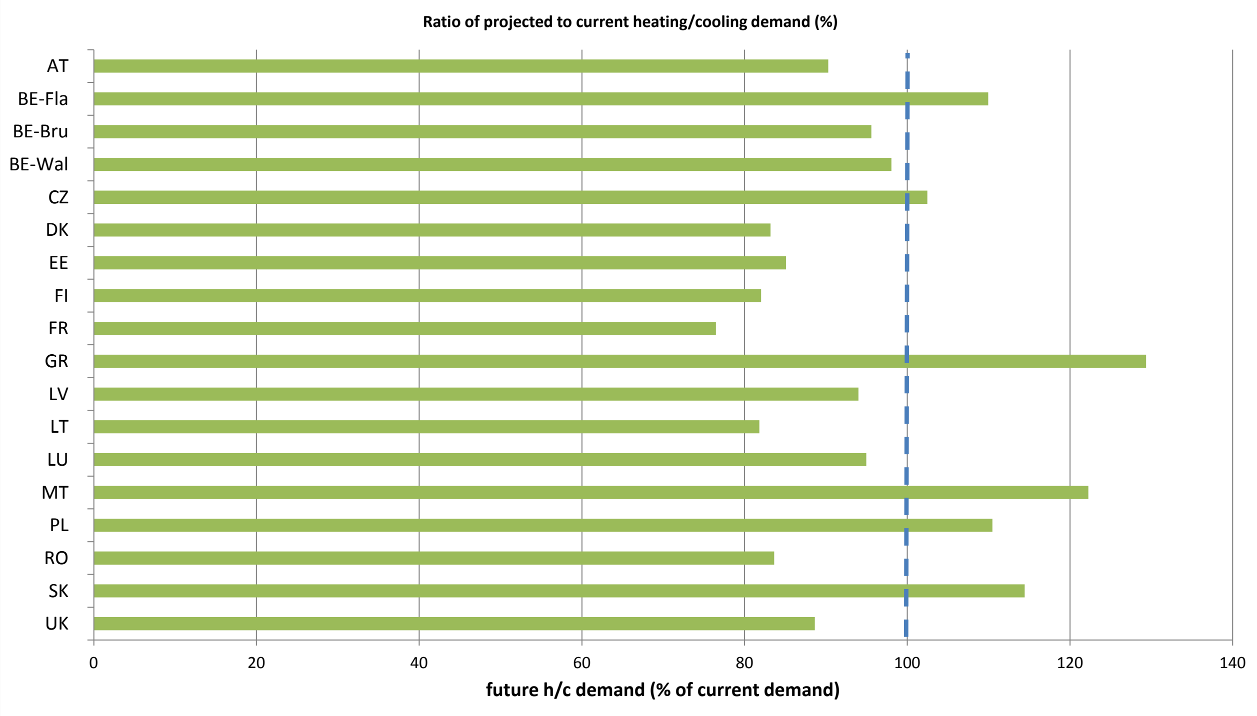


*Figure 1. Ratio of future to current heating/cooling demand in Member States (own figure).*

tial heating and cooling supply points (EED, Annex VIII 1c). For heating demand, municipalities and conurbations with a plot ratio[2] of at least 0.3 and industrial zones with a total annual heating and cooling consumption of more than 20 GWh should be shown in the map. For production, electricity generation installations with a total annual electricity production of more than 20 GWh, waste incineration plants and cogeneration plants of all technology types should be shown. Both existing and planned demand and supply points should be presented on the map (EC, 2013).

An analysis of five regional and city heat maps revealed that the usefulness of the heat map increases with the number of indicators mapped. A heat map ideally contains data layers on the building stock, the population, the energy consumption and the energy infrastructure. Additional features, such as the possibility to zoom in and out and to present summaries and charts next to presenting maps, increase the user-friendliness as well (Cornelis, 2014). This conclusion is now used to assess the presented heat maps in the EU Member States' comprehensive assessment of the national potential of cogeneration and district heating and cooling. Table 2 lists to this end some characteristics of the heat maps:

- Whether or not is referred to an interactive map in the EU Member States' comprehensive assessments[3]
- The resolution of the heat map (based on the heat demand map)
- The extent to which the above listed mandatory data layers are provided
- The presence of optional additional data layers

Heat maps are provided by all but one of the assessed comprehensive assessments, but they show a significant difference in number of mapped data layers and elaboration. Six of the 26 comprehensive assessment reports refer to interactive heat maps, some present data at a high resolution, such as the maps of Austria and of the Netherlands. The resolution of more than half of the maps is based on administrative borders, mostly of municipalities (county level: 2 / municipal level: 8 / level of statistical sectors: 4). The other heat maps use grids to present the data; the grid size varies from 144 to 0.25 ha (1.2 × 1.2 km²: 1 / 1 × 1 km²: 2 / 300 × 300 m²: 2 / 200 × 200m²: 1 / 100 × 100 m²: 1 / 50 × 50 m²: 1).

The heat demand is mapped by 20 authorities; 4 others only provided maps of the plot areas and of the industrial zones, two indicators Annex VIII 1c of the EED refers to; and heat demand maps are not included in comprehensive assessments of two EU Member States. The cooling demand on the contrary is mapped by 10 authorities only. For most Member States, cooling demand is only a fraction of heating demand, and data for cooling demand appear to be less available.

Maps on the existing district heating infrastructure are included in 16 of the 26 comprehensive assessment reports; the level of detail vary from an indication of the connection level per municipality to a simple indication of which municipalities are served by a DH network. Hardly any existing district cooling networks or future district heating networks are mapped.

Maps of the supply points are included in 18 of the 26 comprehensive assessment reports; however only 13 have include all three mandatory supply points: electricity generation instal-

2. The 'plot ratio' is defined as the surface area of the built environment divided by the total area size of the region.

3. Interactive heat maps that eventually have been provided by national authorities, but are not referred to in the EU Member States' comprehensive assessments are not listed.

lations (>20 GWh/a), waste incinerators and existing or planning cogeneration installations.

Eight of the 26 assessed heat maps include additional data layers, next to the mandatory ones. Industrial waste heat and the biomass potential is mapped the most (each included in 5 heat maps); the Spanish comprehensive assessment report even includes a map of the potential excess cooling supply points. The geothermal (included in 3 heat maps) and solar thermal potential is mapped (included in 1 heat map) to a lesser extent.

#### TECHNICAL AND ECONOMIC POTENTIAL STUDIES

Besides providing geographical analysis of the heating/cooling demand and generation, Member States were requested to perform an assessment of the technical and economic potential of district heating/cooling and cogeneration. The Member States had to this end to propose a certain set of 'alternative' scenarios relative to the baseline. To a certain extent, the Member States are free to propose different types of scenarios. Denmark for instance assesses scenarios with more wind, biomass and hydrogen based storage in the energy system. France also identifies two scenarios that are more ambitious than the reference case. Greece calculates the potential for district heating as a function of energy demand density and distance to the heat source. Ireland made a similar assessment.

The guidelines of the Commission and the JRC suggested to carry out a Cost-Benefit Analysis to identify the economic potential. This can be done by comparing the costs and benefits of different individual and centralized generation technologies,

**Table 2. Quality assessment of the heat maps (own analysis).**

| EU MS | Map characteristics | | Mandatory data layers | | | | Additional data layers | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Interactive | Resolution (1) | Heating demand | Cooling demand | DH/C infr | Potential H/C supply points | Industrial excess heat | Biomass potential | Geothermal potential | Solar thermal potential |
| AT | Yes | 50 x 50 m² | ✓ | | | ✓ | | ✓ | ✓ | |
| BE-BRU | No | Stat. sect. | ✓ | ✓ | ✓ | ✓ | | | | |
| BE-FLA | No | 1.2 x 1.2 km² | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| BE-WAL | No | Municipal | ✓ | | | | ✓ | | | |
| CY | No | Stat. sect. | ✓ | | | | | ✓ | | |
| CZ | No | Municipal | ± | | ✓ | ✓ | | | | |
| DE | No | County | ✓ | | | | | | | |
| DK | No | 1 x 1 km² | ✓ | ✓ | ✓ | ✓ | | | | |
| EE | No | | | | ✓ | ± | | | | |
| EL | No | Municipal | ✓ | ✓ | | ✓ | | | | |
| ES | Yes | 100 x 100 m² | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| FI | No | Municipal | ✓ | ✓ | ✓ | ± | | | | |
| FR | Yes | 200 x 200 m² | ✓ | ✓ | ✓ | ✓ | | | | |
| HU | No | Municipal | ± | | ± | | | | | |
| IE | No | Stat. sect. | ✓ | | | ± | | | | |
| IT | No | 300 x 300 m² | ✓ | ✓ | ✓ | ✓ | | | | |
| LT | No | | | | | | | | | |
| LV | No | Municipal | ✓ | ✓ | ✓ | ✓ | | | | |
| LU | No | 300 x 300 m² | ✓ | | ✓ | ± | | | | |
| MT | No | Municipal | ✓ | | | | | | | |
| NL | Yes | Building | ✓ | | ✓ | | ✓ | ✓ | ✓ | |
| PL | Yes | Municipal | ✓ | ✓ | ✓ | | | | | |
| RO | No | County | ✓ | | ✓ | ✓ | | ✓ | | |
| SE | No | 1 x 1 km² | ± | | ✓ | ✓ | | | | |
| SK | No | | ± | | ✓ | ± | | | | |
| UK | Yes | Stat. sect. | ✓ | ✓ | ✓ | ✓ | ✓ | | | |

*(1): resolution of the heating demand map; "Stat. sect." refer to statistical sectors*
*✓: data layer provided; ±: data layer partially provided*

such as high-efficiency cogeneration, waste heat (municipal or industrial), biomass boilers, heat pumps etc. The Cost-Benefit Analysis is proposed to be performed with two different values for the discount rate (which reflects the return that could be obtained by investing in other projects). The 'financial' discount rate would take the perspective of the investor, only investing in projects with an interesting rate of return. The 'social' discount rate would include societal and environmental benefits and is typically lower. The Member States should identify the projects, which are economically interesting from a societal perspective, but not yet from an investor's perspective, and bridge the gap with an appropriate policy incentive. Besides the 'scenarios', a sensitivity analysis could be performed on certain parameters such as the discount rate and the energy price, as they are crucial for the economic viability of the technical solutions.

It could be observed that not all the submitted reports present these data in a straightforward way. For some Member States, the information was given in a specific scenario, but not in a nation-wide aggregated way. For instance, the economic potential for district heating in Greece was calculated as a function of energy density of the region and distance to the heat generation source. UK and Cyprus discuss the technical potential as a function of the specific technology. Many Member States do not mention a discount rate, nor report a net present value analysis, while this was explicitly required by the EED. Most countries did not perform a sensitivity analysis either.

While these analyses are certainly valuable and insightful towards policy makers, it is difficult to compare the results between Member States who followed a different methodology. In this paper, we specifically focus on the results which are comparable between the Member States.

Potential of district heating/cooling compares the current share of district heating and its technical potential and economic potential as a function of total future heating/cooling demand. Mainly Scandinavian and Central European countries have currently a large share of district heating as can be seen in.

The exact results of the cost-benefit analyses are dependent on a range of parameters and scenarios adopted by the Member States, including the replacement costs, geographical and demographical information, discount rate etc. In addition to financial parameters for the Cost-Benefit Analysis, the adopted technical lifetime of the infrastructure is an extremely important parameter as well. The economic potential of district heating and cooling is highly dependent on the energy demand density of the region. Individual heating solutions will usually be most cost efficient for low populated areas. Other factors, such as the presence of an industrial waste heat source or the presence of an already operational district heating infrastructure have an impact on the results as well. In regions without district heating, individual solutions such as efficient boilers and heat pumps are often more cost effective. In new neighbourhoods the cost of district heating/cooling may be reduced, as the heating network can be installed simultaneously with the electricity grid.

A wide variety in technical and economic potential of district heating can be observed. It varies from 95 % technical potential in Belgium – Flanders, to 5 % in Luxembourg, while these regions are in very close proximity and have a similar population density. In addition, neighbouring Germany reports a technical potential of less than 20 %, while a lot more district heating networks are already operational as compared to Belgium. A similar difference is observed between Latvia (LV) and Lithuania (LT), where the technical potential of district heating differs by a factor of two. Some countries report a very low or non-existing economic potential, like Cyprus and Ireland, while others see possibilities for a substantial expansion of current heating and cooling infrastructure, like Poland. Another remarkable difference is found between the assessments of Cyprus and Greece. The former analysis concludes that centralized solutions such as district heating are not found to be economically viable. The latter analysis on the contrary concludes that "heat pumps are not a competitive technology for the generation of energy-efficient heat on the basis of the applicable electricity tariffs and investment cost".

A possible explanation for these apparent discrepancies can be found in the interpretation of the concept of 'technical' and 'economic' potential of district heating/cooling. Belgium for instance, considers the technical potential as the maximum amount of heat demand that could be covered by district heating, regardless of any cost-benefit aspects, which is consistent with the guidelines issued by the European Commission (EC, 2013). Germany on the contrary interprets the technical potential as the share of heating demand that is economically interesting from an societal point of view, using the social discount rate, while it reports as 'economic potential' the perspective of an investor, using the financial discount rate. This is in line with the methodology suggested by Jakubcionis et al., 2015. These two approaches are both considered to be valid, however they can yield a substantially different result.

#### Potential of high-efficient cogeneration

Figure 3 compares the current share of high-efficient cogeneration and its technical potential and economic potential as a function of total future heating/cooling demand. The potential assessments also include the potential for different industrial sectors, calculated separately from the cogeneration potential for residential district heating. The technical potential is again dependent on the approach followed by the individual Member State. The potential for cogeneration is critically dependent on the presence of district heating in the country. Most of the countries with a large share of district heating networks report a significant potential for cogeneration as well, such as Denmark, Sweden, Lithuania, Latvia and Slovakia. Most countries with a currently low share of cogeneration, also report a low economical potential.

For the 'economic' potential however, a rather limited margin for improvement seems available as compared to the currently installed CHP installations. Some countries even report a decreasing economical potential for cogeneration, due to the fact that current subsidy or other support schemes will fade out in the next years. Other countries like Sweden, Romania, Czech Republic and Austria report economic potential which is very close to the existing share of cogeneration . Lithuania and UK report high economic potentials for cogeneration, while the current shares are much lower. For Lithuania, the economic potential includes public investment support in some scenarios. For UK, scenarios with different fuel prices and financial parameters are investigated, where a substantial potential for cogeneration was found in the industry sector and for waste recycling.

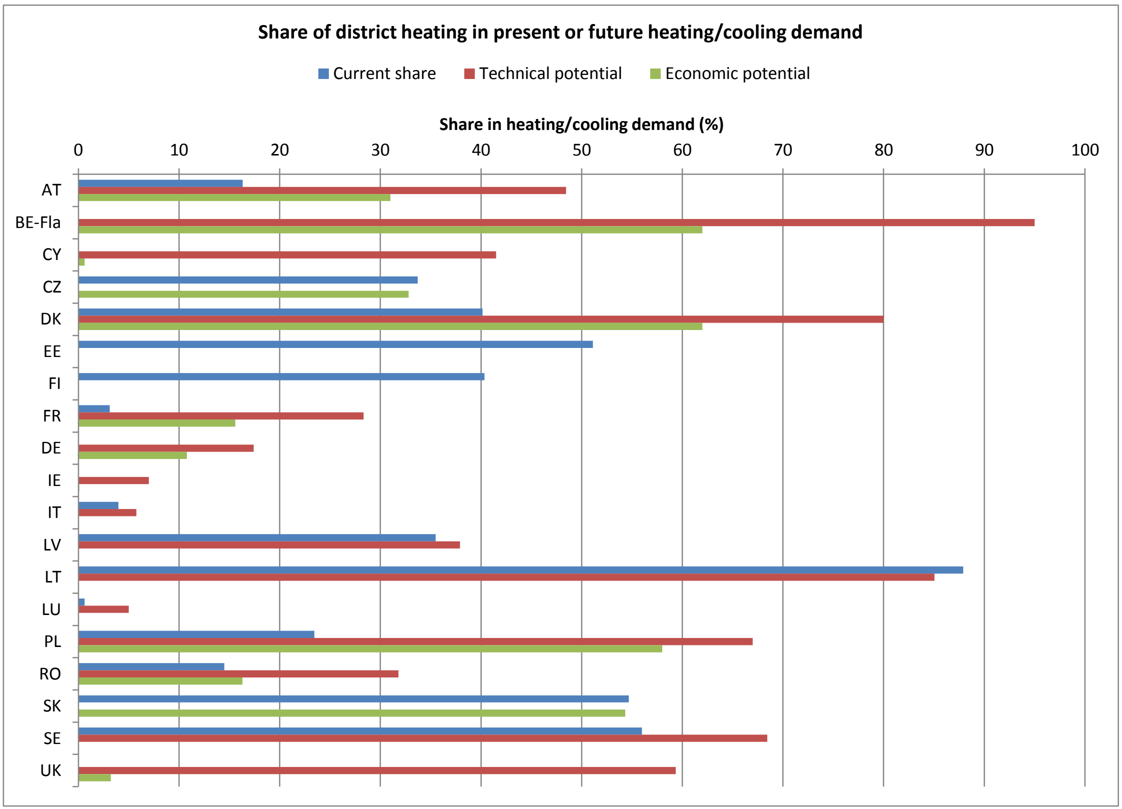


*Figure 2. Current share, technical potential and economic potential of District Heating as a function of total future heating/cooling demand. (own figure). Cyprus (CY) and Ireland (IE) have zero penetration of district heating, other missing data were not found in the national assessments or were given as a function of technology.*

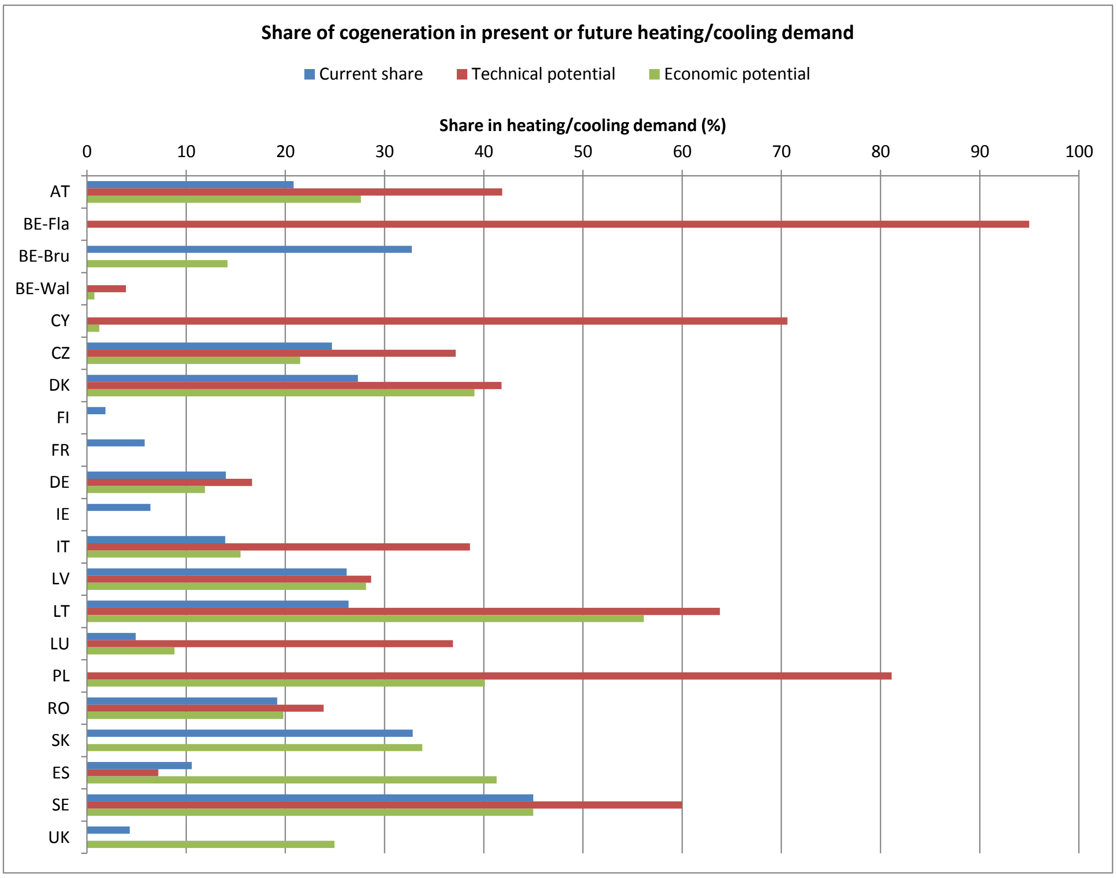


*Figure 3. Current share, technical potential and economical potential of cogeneration as a function of total projected heating/cooling demand (own figure). Belgium-Wallonia reports nearly zero economical potential, other incomplete data reflect data missing in the assessments.*

#### Energy savings

According to the EED, the Member States are required to report on the projected savings resulting from policies aiming at reducing the heating/cooling demand . The EED however leaves considerable room for interpretation of the energy savings. For instance, some countries report a yearly saving in 2030, while others report cumulative energy savings. Other countries report savings per technology, sector or scenario. For cogeneration, one could define primary energy savings compared to a separate electricity and heating production, or include savings by the corresponding building renovation as well. In general, the difference in base case selection of the assessments has proven to be problematic for comparison of energy savings in a consistent way. Table 3 summarizes the reported energy savings by the Member States, the corresponding unit, and comments on how the comparison or baseline scenario for energy savings was selected.

### ANALYSIS OF THE PROPOSED POLICIES AND MEASURES

Annex VIII of the EED stipulates that the comprehensive assessment of national heating and cooling potentials shall include "(g) strategies, policies and measures that may be adopted up to 2020 and up to 2030 to realise the potential in [for additional high-efficiency cogeneration] in order to meet the demand" [that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration, and by district heating and cooling]. The proposed strategies, policies and measures should aim to increase the share of cogeneration, to develop district heating and cooling networks, to encourage the location of new thermal electricity generation installations, industrial plants and residential zones where waste heat can be recovered or can be valorised and to encourage their connection to district heating and cooling grids. Paragraph (j) of Annex VIII adds that "an estimate of public support measures to heating and cooling, if any, with the annual budget and identification of the potential aid element" should be included as well.

The 26 comprehensive assessment reports have been scanned to verify the extent to which such policies and measures (PAMs) are proposed. Table 4 shows the results. A distinction is made between:

- Existing PAMs: policies and measures that already were in place before the EED came into force
- New PAMs: policies and measures that were added to help realising the objectives of Art 14 of the EED
- Considered PAMs: policies and measures the Member State is considering but not yet have implemented
- Whether or not an estimation of the public support measures is included

This analysis reveals that policies and measures are discussed in 22 of the 26 analysed comprehensive assessment reports. Seventeen Member States have reported existing policies and measures. They mainly concern PAMs supporting high-efficient cogeneration and efficient district heating and cooling via mechanisms such as project subsidies, certificates or tax exemptions. Only a few Member States report policies and measures supporting waste heat recovery or the inclusion of heating and cooling as one of the determining factors in urban planning.

Six Member States have reported new policies and measures. They mainly aim supporting district heating and cooling (5 MS: CZ, EE, EL, MT and RO) and cogeneration (4 MS; CZ, EL, PL and RO). However, some new policies and measures aim at the reduction of the heating and cooling demand among end-consumers (2 MS: MT and RO), the replacement of less efficient heating devices by more efficient ones (1 MS:

**Table 3. Reported energy savings with a comment on the selection of the base case.**

| Member State | | Reported energy savings | Unit | Comment |
|---|---|---|---|---|
| Austria | AT | 13 % | % | Primary energy savings compared to 2012 |
| Cyprus | CY | 70 % | % | 70% => 100 units of fuel generate 70 units of electricity |
| Denmark | DK | 209.0 | PJ | PJ Primary energy savings compared to 2012 in the wind case |
| Finland | FI | 1.7 | TWh/year | Only for industrial waste heat |
| France | FR | 186.1 | TWh/year | |
| Germany | DE | 56.0 | Mtonne | Million tonne $CO_2$ saved/year |
| Italy | IT | 0.6 | Mtoe/year | Techno-economic savings potential |
| Lithuania | LT | 2.8 | TWh | Savings by renovation of buildings, not by cogeneration or DH |
| The Netherlands | NL | 12.0 | Mtonne | Extra $CO_2$ emission if CHP units are replaced by coal plants<br>25 PJ savings from residual heat networks |
| Poland | PL | 7.0 | Mtonne | $CO_2$ emission savings in 2014, no outlook data given |
| Slovakia | SK | 6.0 | PJ | Primary energy savings of CHP in 2014 compared to separate production of electricity |
| Sweden | SE | 16.4 | TWh | Primary Energy Savings from expansion of DHC and CHP |

**Table 4. Analysis of the proposed policies and measures (PAMs) (own analysis).**

| EU MS | Existing PAMs | New PAMs | Suggested PAMs | Estimation included |
|---|---|---|---|---|
| AT | | | | |
| BE-BRU | | | X | |
| BE-FLA | X | | | X |
| BE-WAL | X | | | |
| CY | | | X | |
| CZ | X | X | | X |
| DE | | | | |
| DK | X | | | X |
| EE | X | X | | X |
| EL | X | X | | |
| ES | | | | |
| FI | | | | |
| FR | X | | | X |
| HU | X | | | |
| IE | | | X | |
| IT | X | | | |
| LT | | | | |
| LV | | | X | |
| LU | X | | | |
| MT | | X | | |
| NL | X | | | |
| PL | X | X | | |
| RO | X | X | X | |
| SE | X | | | X |
| SK | X | | | |
| UK | X | | | |

MT) and supporting the energy recovery from municipal waste (1 MS: CZ).

Fiveother Member States indicate to consider new policies and measures. The majority aims at supporting district heating and cooling (4 MS: BE-BRU, IE, LV, RO); two Member States explicitly include the planning of district heating and cooling (IE and RO). The other considered PAMs are new support measures for cogeneration (2 MS: BE-BRU, LV) and measures stimulating the energy recovery of municipal waste (2 MS: BE-BRU, RO), the recovery of waste heat (1 MS: CY) and the replacement of less efficient heating devices by more efficient ones (1 MS: CY).

Six Member States have included an estimate of the public support measures to heating and cooling; all the estimates refer to support measures that are already in force.

## Discussion

### DISCUSSION ON RESULTS OF THE ASSESSMENT

Performing a nation-wide cost-benefit analysis for district heating/cooling and cogeneration is not a straightforward task. However, a consistent approach for these analyses is essential for the Commission to track the progress of heating and cooling efficiency in Europe and draft new regulations to accelerate the transition to sustainable heating sources. While extensive guidelines were given by the European Commission and the JRC, the presentation of the results could to a certain extent be reported freely by the Member States. This resulted in a different approach for each Member State. For instance, heating demand was reported using different units, for different sectors and technologies. Some countries reported the technical and economic potential of DHC and cogeneration only as a function of scenario, which complicates comparison with other Member States, who selected different scenarios. In addition, it has to be noted that several countries failed to report all required data to the European Commission.

To improve consistency of the results, one option could be that the reporting process uses a template, which could provide the neutral reader with an overview of the national cost-benefit assessment results without going through the entire documents.

For the technical analyses, different interpretations were found to be used by the Member States. Most countries based this assessment on a geographical analysis, identifying the areas of high heat demand density. Some Member States however reported the technical potential of projects having a positive net present value using the social discount rate, as opposed to the financial discount rate.

The cost-benefit analysis of the Member States was subject to a different set of parameters as well, resulting in different results for otherwise geographically and demographically similar areas. Not only the discount rate, but the selected time horizon of the investment had a significant impact on the results. Nevertheless, several Member States reported a high additional economic potential for district heating networks. The additional potential of cogeneration was more limited and often correlated with the potential for district heating.

Finally, only a few countries reported a nation-wide estimate of the energy savings by district heating/cooling and cogeneration. The exact definition and method of comparing baseline and alternative scenario for the energy savings was highly variable, and the results were found to be mostly incomparable. Hence, an important piece of the puzzle is currently missing, as energy savings are the link between the implementation of Art. 14. of the EED and Europe's energy efficiency targets.

#### DISCUSSION ON HEAT MAPPING

The comprehensive assessment of the potential for the application of high-efficient cogeneration and efficient district heating and cooling has requested the EU Member States for the first time to carry out a geographical analysis rather than purely a numerical analysis of a segment of the energy system[4]. The map had to include heating and cooling demand points, existing and planned district heating and cooling infrastructure and potential heating and cooling supply points.

The assessment of the submitted heat maps has revealed a wide range in quality of these maps, from sophisticated interactive tools at high resolution and additional data layers to a simple indication of some key indicators on county or municipal level.

Although the EU Member States could limit the required heat mapping to a simple geographical identification of the demand points, infrastructure and potential supply points, the more elaborated heat maps clearly show the added value of a geographical quantification of the heating and cooling demand, the potential to expand heating and cooling infrastructure and of the potential of various sustainable heating and cooling sources. One can hence expect that, in light of this added value, geographical analysis tools for (sustainable) energy purposes might become the standard analysis method, outperforming the purely numerical analysis tools. The obligation to generate heat maps, as requested by the EED Art 14, might hence have created a momentum in developing and using such geographical analysis tools. Such a geographical quantification is however a daunting task, as illustrated by the described methods in some of the comprehensive assessment reports. It requires the availability of the right energy data, the distribution of these energy data into smaller units and the allocation of these energy numbers to geo-references. It requires both appropriate methods for data processing and tools for mapping. The wide range in quality of the heat maps show that not every EU Member State has these methods and tools at hand. A cross-over from more experienced and equipped countries to less experienced and equipped ones is necessary to diffuse geographical analysis tools in the whole of the EU.

#### DISCUSSION ON PROPOSED POLICIES AND MEASURES

It is questionable whether the proposed policies and measures on CHP and DH/C will be sufficient to bridge the gap between the technical and economic potential of high-efficient cogeneration and efficient district heating and cooling in all Member States. On the other hand, carrying out a full comprehensive assessment on cogeneration and district heating/cooling, designing policies based on these results and having these approved by the national parliaments within 3 year, is an extremely challenging task. Unsurprisingly, Member States put a strong emphasis in their reports on existing policies and measures. In addition, some Member States failed to provide sufficient information in their comprehensive assessment reports.

#### CONCLUSION

The objective of this paper was to verify whether Article 14 of the EED has created a momentum to integrate efficient heating and cooling in the national policies of the EU Member States. The mandatory comprehensive assessment on the potential for the application of high-efficiency cogeneration and efficient district heating and cooling has forced the EU Member States to reflect on the evolution of the heating and cooling demand and on the role high-efficient cogeneration and efficient district heating and cooling can play in the remaining demand. Although the quality of the comprehensive assessment report varies considerably from one to another Member State, Art. 14 of the EED has added district heating and cooling to their political energy agenda, especially in those Member States that have no tradition in this energy technology.

It is hence highly recommendable that the European Commission requests the Member States to update their comprehensive assessment reports by the end of 2020 in order not to lose this momentum. It is also recommended to issue stricter guidelines on the assessment methods and a template for reporting, ideally including a fixed set of mandatory indicators. A collaboration between EU Member States in the meanwhile might support the diffusion of assessment methods and geographical analysis tools. It might also support the development of efficient district heating and cooling networks, especially in those Member States with significant potential.

4. A first reference to geographical information on heating and cooling is made by Article 22 of the Renewable Energy Directive (2009/28/EC) titled "Reporting by the Member States". §3(c) requested the EU Member States to indicate in their first reports whether they intend to "indicate geographical locations suitable for exploitation of energy from renewable sources in land-use planning and for the establishment of district heating and cooling."

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